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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

JULY, 1923

AGE AND AREA
HUGO DE VRIES

BOTTLE GRAFTING
BLAKESLEE AND FARNHAM

MULTIFLOROUS BURT OATS
COFFMAN AND QUISENBERRY

ORNAMENTAL PARASITES IN BAMBOO
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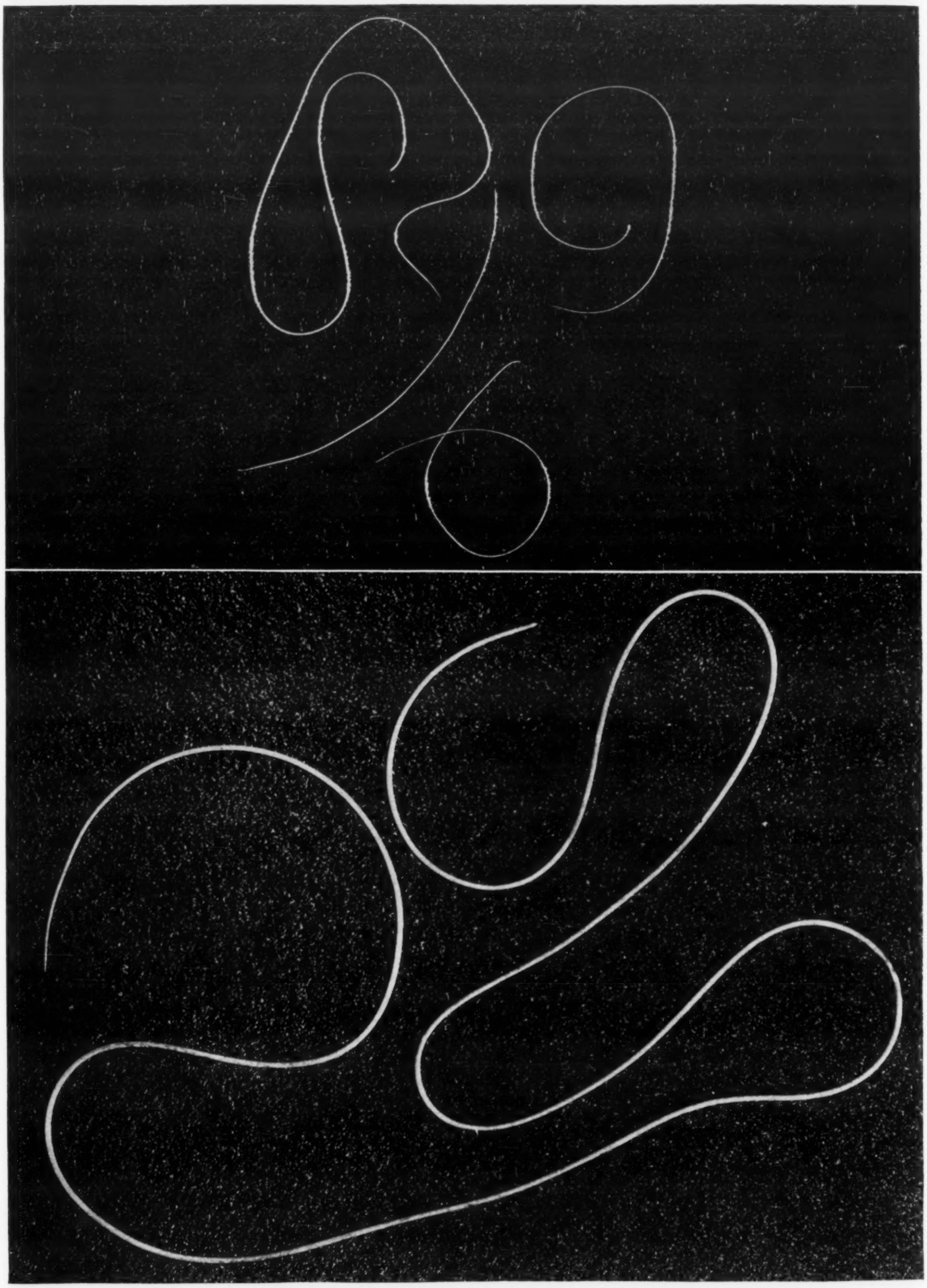

MALE AND FEMALE HAIRWORMS

The genus Agameris contains some of the larger species of hairworms. The average length of the females of *Ag. decaudata* (bottom) is nearly eleven inches; that of the males (top) is not quite three inches. Many nematodes are parasites, and nearly every kind of plant and animal is an actual or potential host for one or more species of them. Nematodes are not immune from attacks by their own kind; in some cases they even prey on individuals of the same species, something very unusual among anything but human parasites. Their parasitic habit gives nematodes great economic importance. Some species are a serious menace to crops and herds, while others prey on our most dangerous insect pests and offer a promising means of combating them.

INTERSEXES IN NEMATODES

G. STEINER

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STIMULATED by the experiments of Goldschmidt on the Gypsy Moth the writer carried out extensive experiments in the winter and spring of 1921-22, in which he attempted to cross several morphologically closely related free-living nematode species.[1] The chief aim was to see if intersexes (as the term is used by Goldschmidt) could be produced by hybridization of certain easily reared species.

Intersexes are individuals which possess the sexual characters of one sex mixed with the characters of the other. Such cases have been long known and some of them were designated hermaphrodites, gynandromorphes, etc. Modern experiments have showed that whole series occur in which the characters of a male and female are more or less mixed, thus representing all possible steps between a true female and a true male.

Mention of some intersexes already existed in nematode literature; there were several short accounts of them in some species of *Mermithidae*, and a description of those reported in other genera is given in later paragraphs of this paper.

Unfortunately my experiments did not have the desired results. It seems to be very difficult to cross the species of the genera mentioned in the foot note. Thus far my experience agrees with that of Maupas, published in a posthumus paper edited by Caullery.[2]

During the last few months the writer was called upon to identify a large number of Mermithidae. Numerous intersexes were observed. Since the sex problem is today a center of biological discussion, a description of these intersexes is certainly of some interest at this time.

Intersexes in the Hair-Worm

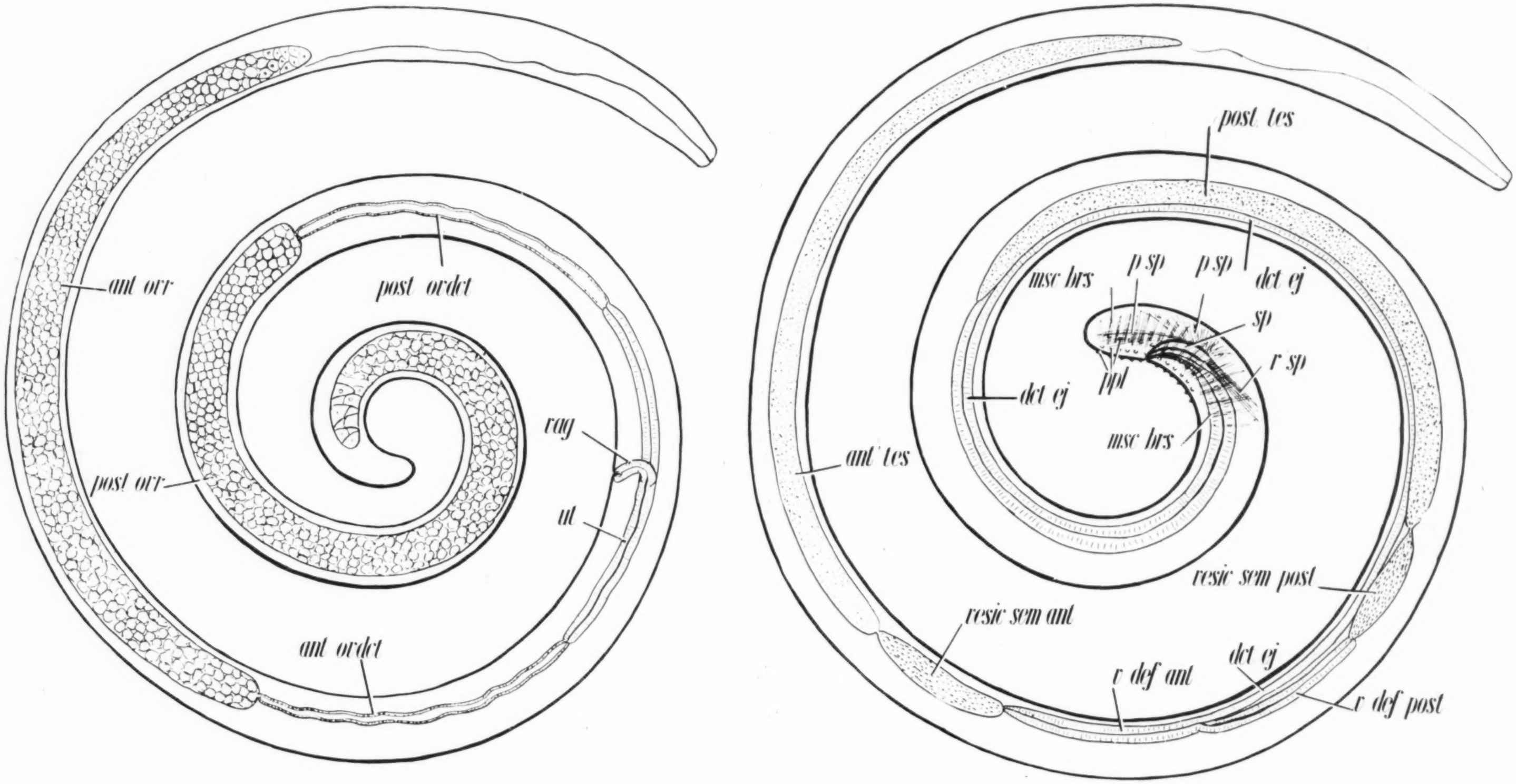
Hitherto every investigator who has studied any considerable number of *Ag. albicans*[3] or related forms, mentions the presence of intersexes[4] in this species. Meissner in his splendid study of this form describes as early

[1] For the opportunity to carry on these experiments I am greatly indebted to the authorities of Yale University and the staff of the Osborn Zoological Laboratory, New Haven, Conn. Species of Rhabditis, Plectus, Cephalobus and Diplogaster were used in these experiments, an account of which will be given in a later paper.

[2] Maupas, Emile, Essay d'Hybridation chez des Nematodes. Bull. Biol. de la France et de la Belgique. T. 52. 1919.

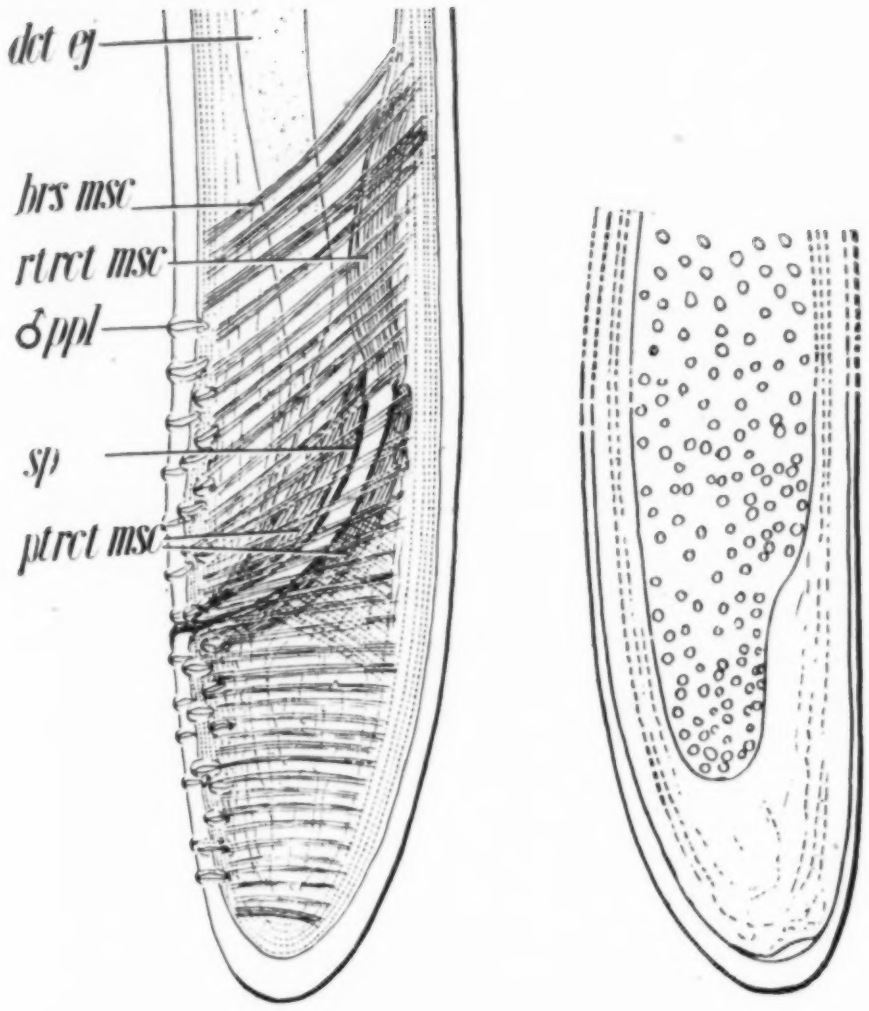
[3] During recent experiments it was found best to split the former genus Mermis into several new genera. In the future the genus Mermis will include only those forms with four head papillae, two mouth papillae, amphids situated laterally in the same level with the head papillae, mouth terminal, vagina S-shaped; type species *M. nigrescens Duj.* The new genus Agamermis will include forms with six head papillae, no mouth papillae, amphids mostly behind the lateral head papillae, or slightly shifted dorsad, mouth terminal, vagina S-shaped. In entering the host the preparasitic larva of this genus drops five-sixths of its body through self-amputation at a preformed node. Our type species, *Ag. decaudata* resembles very much the former *Mermis albicans* as described by Meissner and partly by Hagmeier, but differs from it through the structure and position of the amphids or lateral organs, and the cells around the esophagus. Furthermore it is not known whether in the latter form the tailpart of the larval body is dropped by self-amputation, as in *Ag. decaudata.* We are sure that *M. albicans* of earlier investigators includes perhaps a number of different species. For further details, see the preliminary paper: COBB, STEINER, and CHRISTIE, *Agamermis decaudata*, a Nema Parasite of Grasshoppers and Other Insects. *Journal of Agricultural Research*, Vol. 23, No. 11, 1923.

[4] They were not termed such, but were called hermaphrodites or "Zwitter."



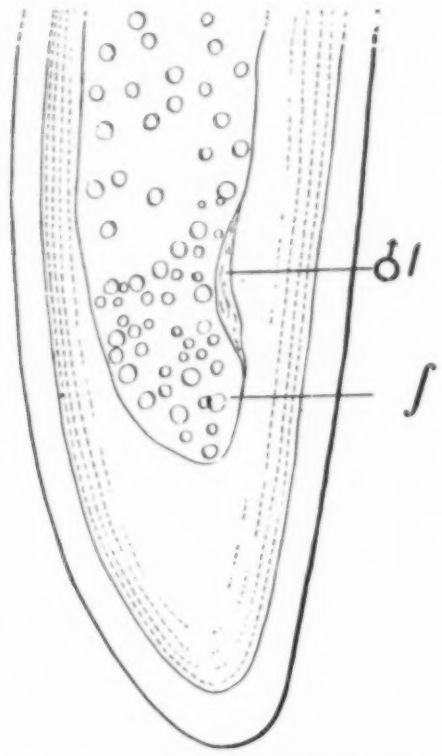
INTERNAL STRUCTURE OF MALE AND FEMALE HAIRWORMS

FIGURE 1. These outline drawings are not strictly to scale and only the reproductive organs are shown, these being the parts of most interest in connection with this article. The nematodes are such slender animals that paired organs would have no space to lie side by side, and so are arranged "tandem." The nematodes offer a unique field for the experimental study of many biological problems. Under the microscope the physiologist can actually observe many metabolic processes that he can study only indirectly in larger organisms. More variations in reproductive processes and in the sex ratio are found in nematodes than in any other animals. Species are known in which no males or only one male is produced to five hundred females, and others in which ten times more males occur than females, and between these extremes are species in which any intermediate ratio can be found. *ant. ovr*, anterior ovary; *ant ovdct*, anterior oviduct; *post ovr*, posterior ovary; *post ovdct*, posterior oviduct; *ut*, uterus; *vag*, vagina; *ant test*, anterior testis; *dct ej*, ductus ejaculatorius; *msc brs*, bursal muscles; *ppl*, male copulatory papillae; *p sp*, protractor muscles of the spicula; *r sp*, retractor muscles of the spicula; *sp*, spiculum; *v def ant*, anterior vas deferens; *v def post*, posterior vas deferens; *vesic sem ant*, anterior seminal vesicle; *vesic sem post*, posterior seminal vesicle.



TAIL END OF MALE AND FEMALE NEMATODES

FIGURE 2. Intersexes are individuals having the reproductive organs of one sex and, in addition, certain organs or tissues typical of the other. All of the intersexes so far observed in nematodes have been females in which certain typically male parts are present. Above is shown the tail end of a normal female (right) and of a normal male (left), showing the male organs that are found in intersexual females (Figures 5-8). *dct ej,* ejaculatory duct; *brs musc,* bursal muscle; ♂ *ppl,* male papilla; *ptrct msc.,* protractor muscle; *rtrct msc,* retractor muscle; *sp, spiculum.*



A SLIGHTLY INTERSEXUAL FORM

FIGURE 3. Tail end of female *Ag. decaudata,* showing a small amount of male tissue (♂ t). Goldschmidt experimentally produced "consecutive intersexuality" in moths by crossing related races. These individuals would begin life as females and gradually change to males, at the same time losing their female characters. He accounted for this change by assuming that the sex determiners of the different races used in the experiment had a different relative rate of activity, and that an initially slow-working "male factor" would gradually increase in activity until it overshadowed the "female factor," when the individual would change from a female to a male.

as 1854 three intersexual females and is very much puzzled over this unusual combination of male and female characters.

The majority of the specimens of *Agamermis decaudata* which I have had the opportunity to study came from Falls Church, Virginia, and were collected by Mr. J. R. Christie. It was very striking that the specimens with intersexual characters were as numerous as, or even more numerous than, normal females.

One important fact, to be noted at the outset, is that *hitherto only intersexual females have been observed,*— that is, all specimens with intersexual characters were females; the female sex organs were completely and normally developed. Vulva, vagina, uteri and ovaries were normal and in most of the animals eggs were present in the oviducts and uteri. Up to the present the writer has never seen a male with intersexual characters, and, as far as he knows, no other investigator has.

Let us now first see what a normal female and male of this species look like:

The two sexes may be distinguished from each other with the naked eye, as they are in most cases distinctly different in size. The photographs, (Frontispiece), show a female and several males that were found together in the soil. The female is several times larger than the male. The average length of six females was found to be 293.7 mm., ranging from 190 to 380 mm., whereas the average length of ten males was only 63.5 mm., rang-

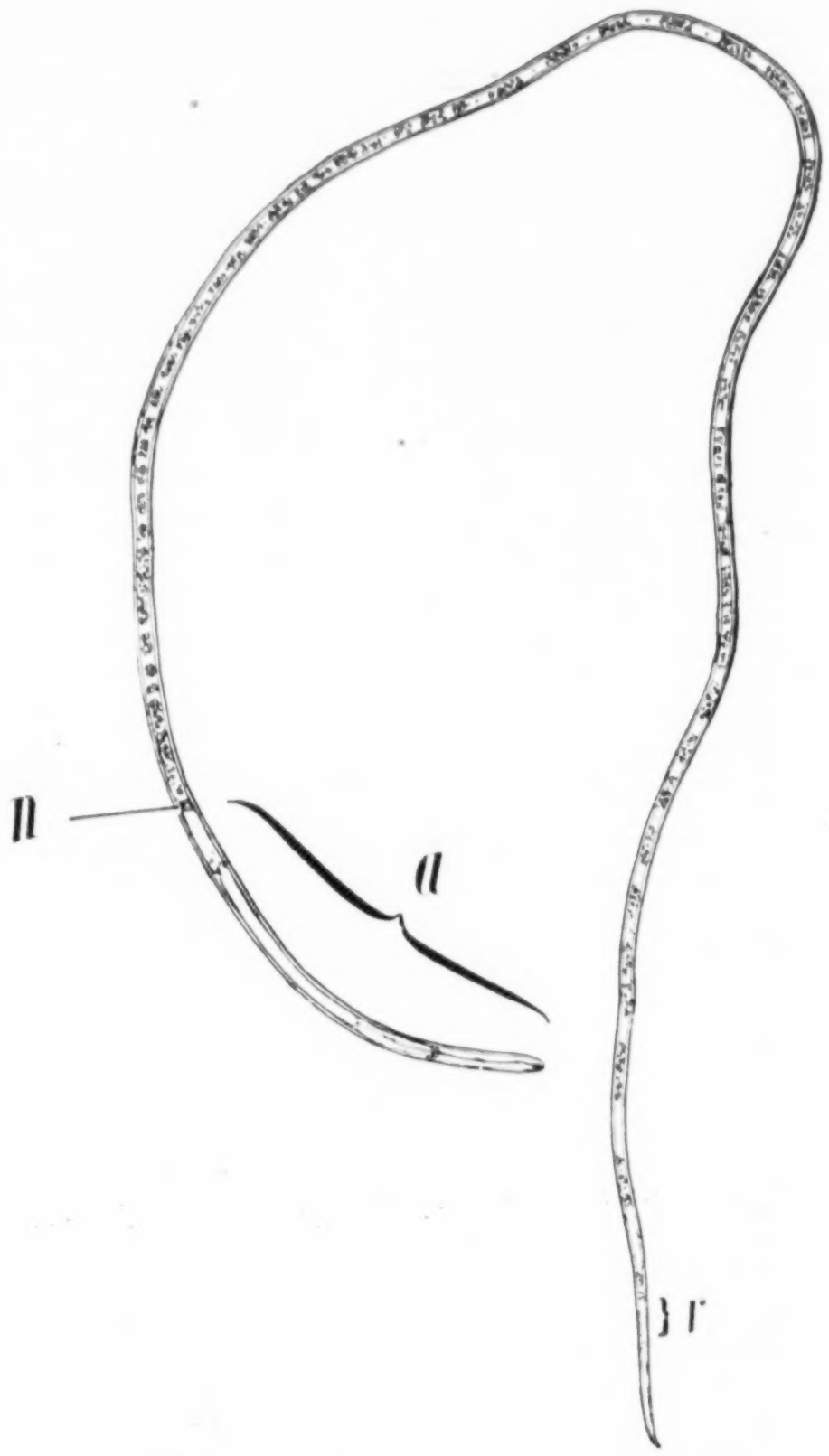
tractor muscles of the spicula; *r sf,* retractor muscles of the spicula; *sem ant,* anterior seminal vesicle; *vesic sem post,* posterior seminal vesicle. deferens;

ing from 42 to 104 mm. Hagmeier gives for the males of *Ag. albicans* a length from 29 to 80 mm., for the females 38 to 320 mm. Occasionally very small females may also be seen in this species exceeding in length only slightly, or not at all, the average male. Unusually large males have also been observed, attaining the length of the smaller females. While the size may therefore have a certain value in determining the sex of individuals the gonads and copulatory organs are nevertheless the chief characters. The female sexual opening, the vulva, is a narrow transverse fissure near the middle of the body. It leads into a tubular vagina opening at right angles into the uteri. They are outstretched, one forward the other backward, and merging through the oviducts into the ovaries (Fig. 1).

The male sex opening, however, is situated near the tail end, and combined with a copulatory apparatus consisting of two cutinized spicula and the muscles needed to move them. The *ductus ejaculatorius*, succeeded by the *vas deferens*, leads to two testes of which the one is outstretched forward and the other backward. Furthermore, so-called bursal muscles are present in the tail end of the male on each side a left hand and a right hand series. They are slightly inclined to the body axis and by their action the tail end of the male is enabled to embrace in a spiral manner the body of the female. Besides these organs there are numerous papillae on the male tail end, being the endings of nerve fibres, as shown in Figures 1 and 2.

Thus the organization of the female *Ag. decaudata*, is distinctly different from that of the male. Hagmeier observed another difference between males and females of *Ag. albicans*, namely, the size of the amphids (Cobb) or lateral organs, which he says are smaller in the female than in the male. In our specimens we were not able to observe this distinction.

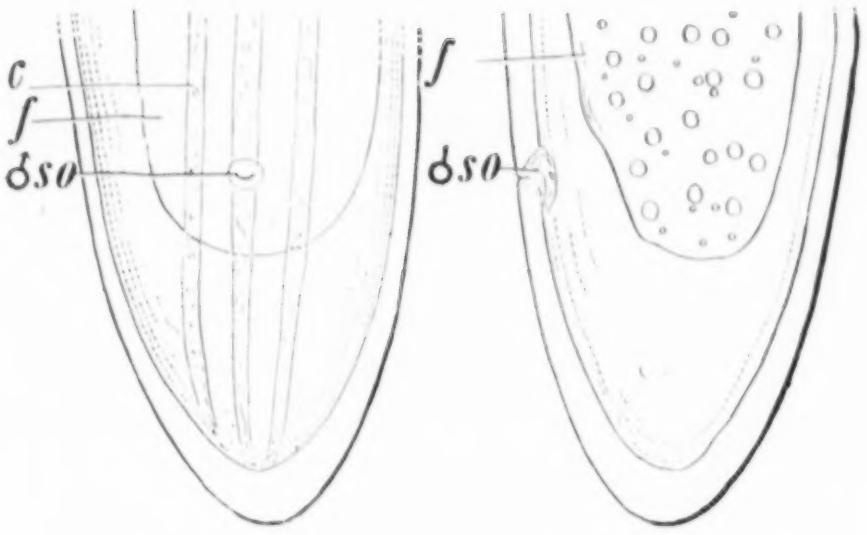
The intersexes observed in American *Ag. decaudata* and now about to be described, are, as already mentioned, all



FREE-LIVING LARVAL FORM

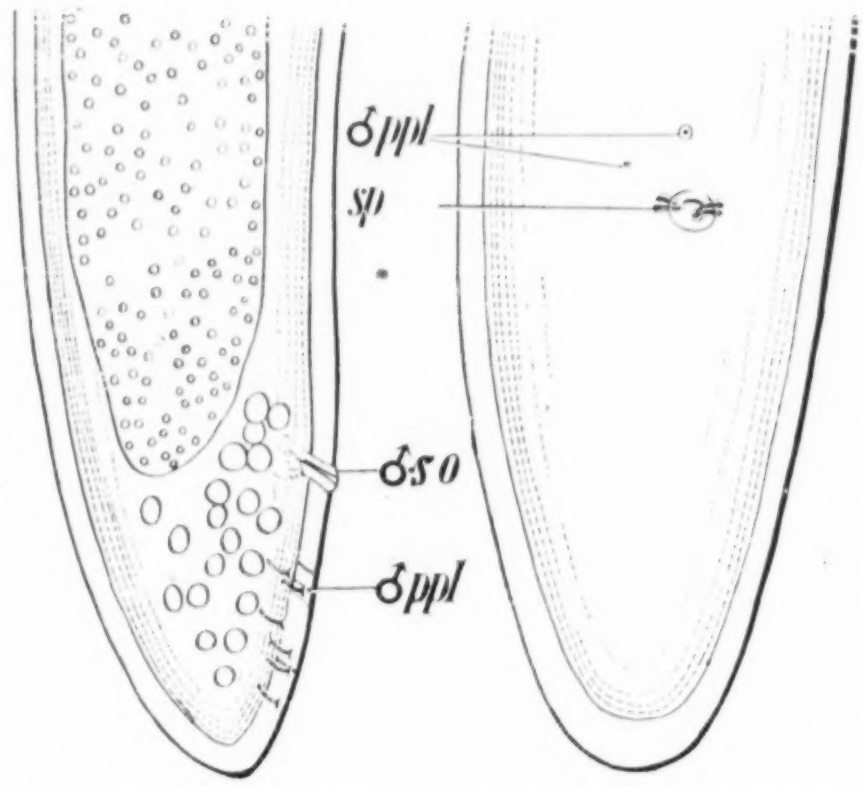
FIGURE 4. The first larval stage of *Ag. decaudata* is free-living, while the second larval stage is parasitic upon grasshoppers, roaches and possibly other insects. When the larva enters the host or shortly afterward about five-sixths of the body is dropped and only the head end (*a*, in figure) continues to live and grows into the adult. Division of the body takes place at a preformed node (*n*). This is one of the most remarkable cases of self-amputation known and was first observed by Dr. N. A. Cobb. It shows that the part of the alimentary tract that is homologous with the rectal and anal regions of other nematodes (*r*, in figure), is dropped in this species. Therefore what openings occur at the tail-end of the adults can only be regarded as sex openings and never as anal openings.

females. They all have complete normal female sex organs and most of them normal eggs in the uteri, and all were found encoiled and copulating



TAIL OF INTERSEXUAL FEMALE

FIGURE 5. Two views of the tail of female *Ag. decaudata*, having a male sex opening (♂ *so*). In the normal female no such openings occurs, and this cannot be considered a rudimentary anal opening because that region has been lost in the adult form (see Figure 4). It is difficult to arrange intersexual characters in a very definite graded series because in some cases one male organ will be highly developed and in other individuals this organ will be rudimentary and others will be much more prominent. *c*, sub-median longitudinal chord; *f*, fat body; ♂ *so*., male sex opening.



MALE CHARACTERS MORE HIGHLY DEVELOPED

FIGURE 6. Tail ends of two females showing more marked intersexuality. The individual on the left has a male sex opening (♂ *so*) and male papillae (♂ *ppl*). The one on the right has two rudimentary spicula (*sp*), and male papillae much less developed than the other specimen. Irregularity in the development of the male organs is characteristic in these intersexes. It is believed that this is due to the fact that these forms are produced by hybridization of different races, in which the time and rate of differentiation of the sex organs vary considerably.

with males. The intersexual state is only to be determined by examination of the tail end. This tail end has more or less the structure and organization of the tail end of a male. We have pictured such transformed female tail ends in Figures 4 to 8. All grades of transformation can be seen from the typical female to a typical male tail end (Figure 2).

Figure 4 is the tail end of a female which shows only a small amount of tissue (connected with the fat body) which has to be regarded as tissue of a male character, since in the normal female no such structure exists.

A more pronounced intersexuality is developed in the female whose tail end is sketched in Figure 5. Here a rudimentary male sex opening is present. It may be said that this structure should be compared with an anal opening and be designated as such. The ancestors of Agamermis certainly once had a complete alimentary tract, and therefore also a functional anal opening. The figured rudimentary openings could be said to be a rudimentary anal opening, homologous with the anal openings of other female nemas, but the ontogenetical development of our forms precludes such a possibility. As Cobb first observed, and as described in the above-mentioned preliminary paper[3], the young larva of *Ag. decaudata* in entering the host loses about five-sixths of its total body length by self-amputation. What develops into the adult *Ag. decaudata* is only the small head part of the preparasitic larva, shown in Figure 4. At a point about one-sixth of the larva's total length from its head end a small series of coin-like cells develops, forming a distinct node. In entering the host the larva drops all of its body posterior to this node by breaking in two at this point. Sometimes the posterior part of the larval body does not enter the host at all, breaking off as soon as the head of the larva has worked its way into the host. In other cases the whole larva enters the host

and the act of self-amputation takes place later.

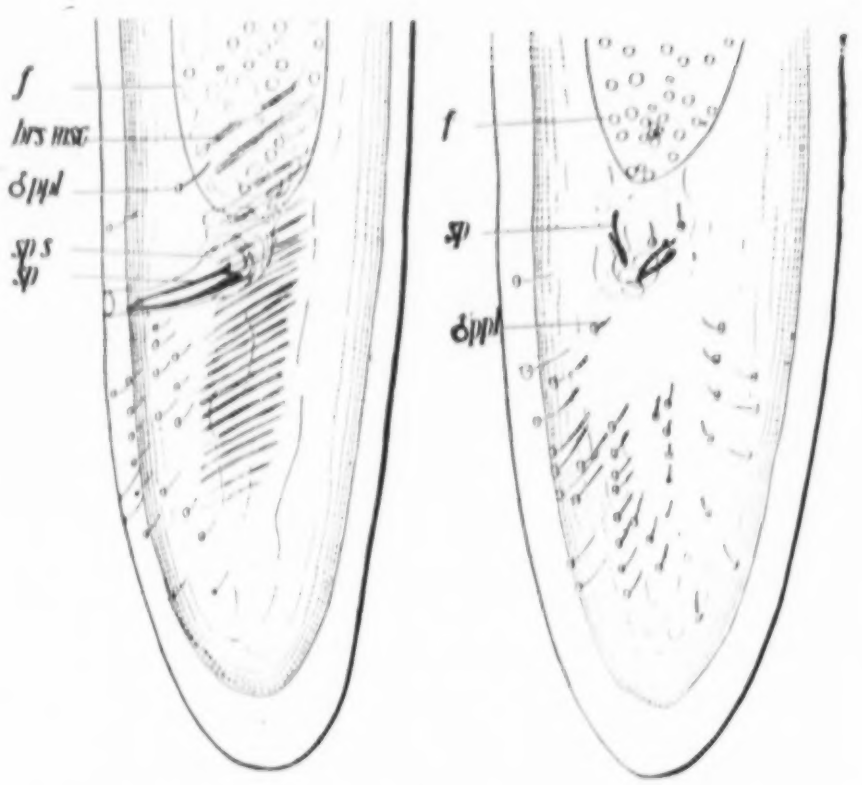
It follows from these facts that the above-mentioned openings of the female tail end of *Ag. decaudata* and perhaps of other female Mermithids can not be regarded as rudimentary anal openings, but must be sex openings, as all tissues which are homologous with the posterior intestine, the rectum, and the anus of the majority of adult nematodes are dropped by the Agamermis larva when the act of self-amputation takes place.

Furthermore the relative frequency of these openings, and the fact that such female tail ends form a graded series linking the normal female and the normal male tail end, speaks against the conception that they are anal openings. If we take this grade of transformation out of the series, the other members of it could not be understood or placed, whereas by regarding it as a reduced male sex opening, it completes a natural structural series that can be understood without difficulty. Hagmeier too regards these openings as rudimentary male sex openings and not as vestiges of an anal opening.

Figure 6 is a sketch of two female tail ends, one of which has not only the male sexual opening, but also a number of male papillae. The other represents a further step to more pronounced intersexuality. There is a rudimentary male sex opening, and also two very small spicula and traces of two male papillae.

Much more pronounced is the intersexuality of the female of which the tail end is pictured in Figure 7. The first gives a lateral, the second a ventro-medial view. A distinct sex opening is present as well as spicula, which are asymmetric; the spiculum of the left side consists of two separated pieces. Some tissue belonging probably to the sheaths of the spicula is also developed. Numerous bursal muscles and male papillae are also present, the latter not fully grown.

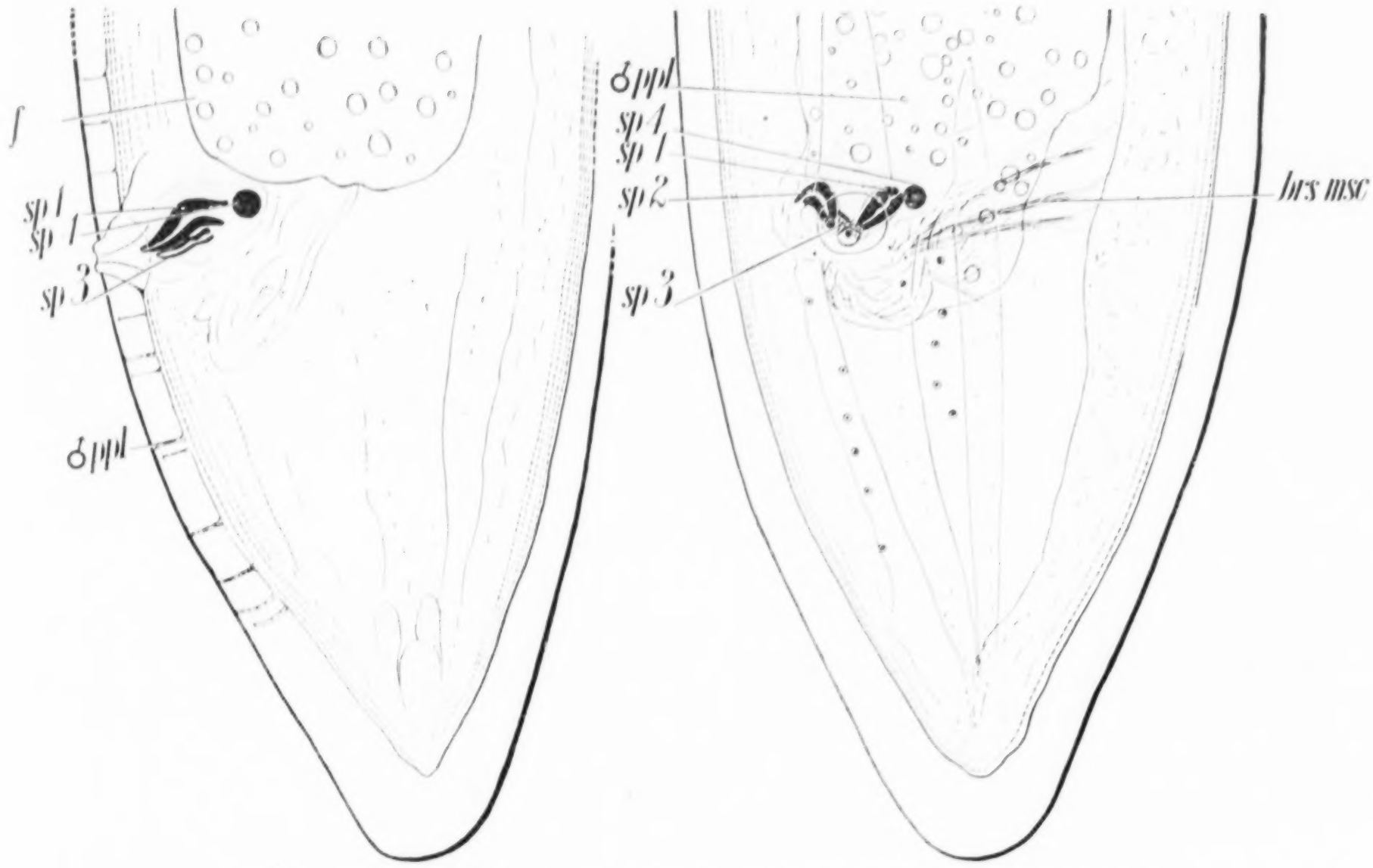
The tail end of an intersexual female sketched in Figure 8 is of particular interest, having four pieces of spicula; morever, they are asymmetric left to right; those at the left have the general form of spicula, the one being smaller than the other. At the right, there is, besides a somewhat normal-shaped but small spiculum, a globular body. Tissue has developed around the spicula, also a sex opening can be observed as well as some few bursal muscles. Male papillae of more rudimentary character are also present.



WELL-DEVELOPED SPICULA

FIGURE 7. Two views of a female with well developed spicula (*sp*), bursal muscles (*bur musc*) and papillae (*δ ppl.*). It must be borne in mind that all the individuals shown in these illustrations have in addition to the male organs a complete and functional set of female organs. Left, lateral view; right, medio-dorsal view; *sp s*, spiculum sheath.

Three more advanced cases of intersexuality were mentioned and described by Meissner in *Ag. albicans*. I myself have not yet seen such high grade intersexes. In these three specimens of Meissner even the size seems to have been involved in the transmutation toward the male. He states that all three of these females were dwarfs, compared with normal females, and had only the length of males. It accords with this that the other male characters also were more developed than in the specimens above described. Meissner says that the tail ends of his females were completely masculine, with two normally formed spicula of



TWO VIEWS OF A HIGHLY INTERSEXUAL FEMALE

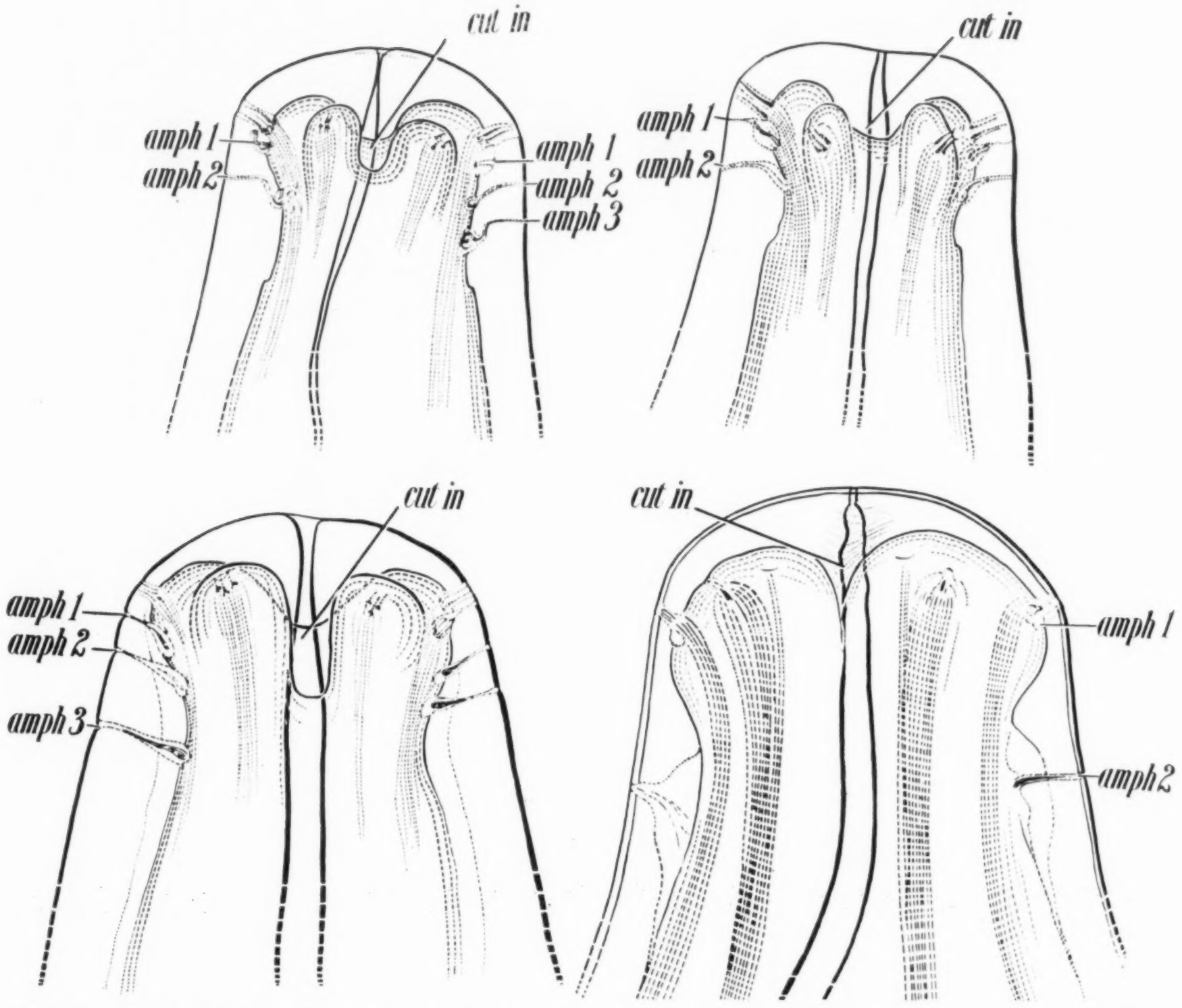
FIGURE 8. This female has a double set of male spicula (*sp* 1-4). Three are normal in shape, and the fourth is represented by a spherical body. Notice that there are much fewer papillae than in the female shown in Figure 7. These intersexes are probably due to natural crossing of distinct races or closely related species, as were the intersexes of the gypsy moth produced artificially by Goldschmidt. Left, lateral view; right, ventra-submedial view; *f*, fat body; ♂ *ppl*, male papilla; *sp* 1, spiculum of the left side; *sp* 3, second spiculum of the right side; *sp* 4, globular second spiculum of the left side; *burs musc*, bursal muscle.

equal length and thickness with the sheaths well developed, but the muscles around the spicula were not as strong as in the true male. However, the bursal muscles, the rows of male papillae, and even the general form of the tail end was exactly like the normal male. But there was no trace of male gonads and ducts. Very interesting it seems to me is Meissner's statement that in the intersexual females the eggs were, though normal, somewhat smaller.

Undoubtedly these intersexes are the most pronounced of this kind hitherto observed in Mermithids. They allow us to construct a complete series of intersexual females with all possible grades between a normal female and a female with complete male secondary sex characters.

As already stated, nearly every investigator who has studied carefully adequate material of *Ag. albicans* has observed such intersexes. Intersexuality seems in this species of *Agamermis* to be a rather common phenomenon. *As far as we know there is no other group of animals known today in which intersexes are observed in such numbers under natural conditions and normally produced.* This seems to be a fact specially to be noted.

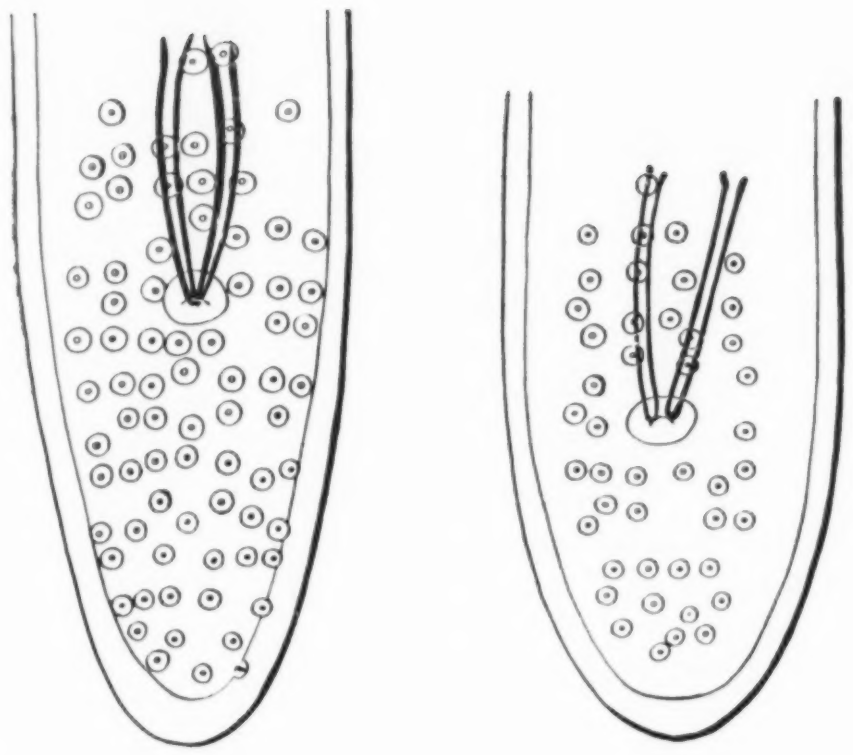
What are the causes of these conditions? As yet we do not know, but there are some other facts about *Agamermis decaudata* and related forms which may indicate where we must look for an explanation. Recently intersexes have been produced experimentally by several investigators, as by Goldschmidt in *Lymantria dispar;* by Keilin and Nuttal in *Pediculus capitis* and *P. corporis;* by Sexton and Huxley in *Gammarus chevreuxi* and related



VARIATIONS IN HEAD ORGANS IN SPECIES PRODUCING INTERSEXES

FIGURE 9. The head organs of most species of nematodes are very constant in form and position. The function of the amphids (*Amph* 1-3) is not definitely known, but there is reason to believe that they are chemical sense organs. The fact that they are so similar on different individuals of the same species makes them of great value in the systematic classification of nematodes. In the case of *Ag. decaudata*, however, we find a striking exception to this rule, for great variation is observed in the number and position of the amphids. This is further evidence of the existence of numerous closely related species which intercross in nature. *Amph*, amphid; *cut in*, cuticular incision between the papillae of the left and the right side.

forms, by Bridges in mutants of *Drosophila melanogaster* and by Sturtevant in *Drosophila simulans*. In all these cases intersexes resulted from hybridization of closely related genotypes. Are there signs that also in our case the observed intersexes could be the result of hybridization of races or genotypes closely related and living mixed with each other in nature? This appears to be the fact. Many difficulties arose as I tried to identify the material brought to me. In the taxonomy of nematodes the structure of the head end and chiefly the organization, the location and number of the head sense-organs are of high importance. This is particularly true in the Mermithids, where other characters for the distinction of the species are very few in number and many of them to be seen with great difficulty or only on adult specimens. Therefore, a close study of the head end and its sense-organs is absolutely needed for a good identification. There are two kinds of head sense-organs in most of the nematodes—the *papillae*, which are claimed to be organs of touch, and the *amphids* (Cobb) or *lateral organs*, which are



TAIL ENDS OF NORMAL MALES

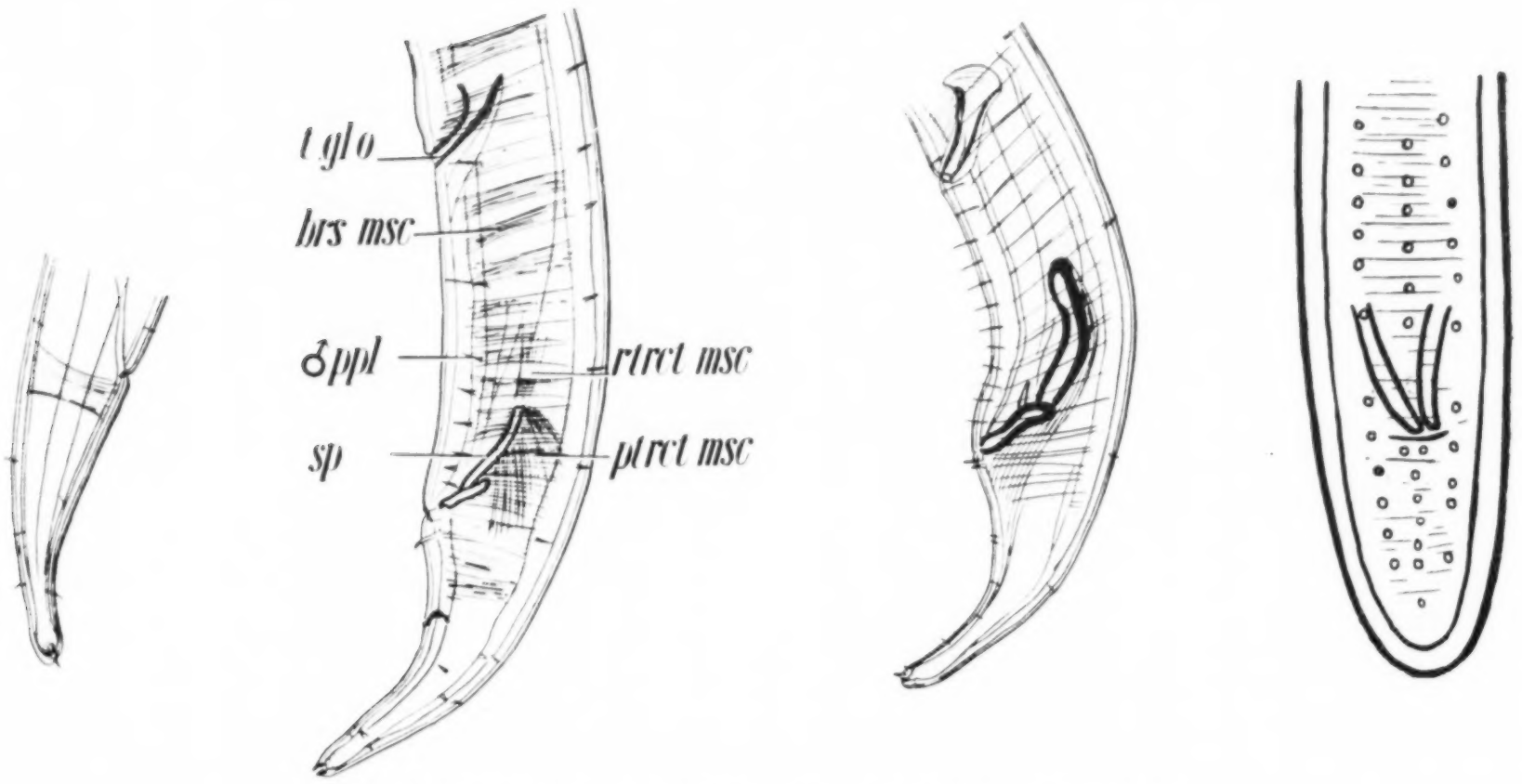
FIGURE 10. In addition to the variation in the head organs of this species, other normally constant characters are unusually variable. This shows the tail ends of two normal males of *Ag. decaudata.* Note the considerable variation in the position and number of the papillae. These differences are greater than are found in other species of nematodes.

probably chemical sense organs. These organs are of very constant nature in nearly all nematode species, and the amphids, or lateral organs are especially of high value as specific characters. In the Mermithidae this is particularly true. The adult specimens may be identified more or less easily by the aid of the sex organs, but the larval specimens can only or best be distinguished by the sense organs of the head. The position, the size, and the structure of the amphids is very different in different species of Mermithidae, although within the species, with few exceptions, very constant. Such exceptions are *Ag. decaudata* and related forms. The number, the structure and the position of the amphids varies here very much, but other significant and easily perceptible differences have not yet been discovered. There are differences also in the shape of the tail end, but these are insignificant. Perhaps the number of metabolic cells along the esophageal tube may be of taxonomic use if more were known about them.

Figure 9 shows the head ends of specimens of *Ag. decaudata,* all differing from each other in respect to the amphids. Why in this form are the amphids so inconstant, while they are so constant in most of the other nematodes? Is it not that we have in *Ag. decaudata* and related forms, not sharp-cut species, but an association of different races or genotypes and numbers of hybrids between them? These races are perhaps continually crossing and it is thus that such a multitude of structural forms in the head end comes about. The numerous intersexes are another result of these crossings between closely related genotypes. In the light of the experiments of Goldschmidt and the other above-mentioned investigators, where intersexes resulted from hybridization of closely related forms, it is highly probable that there is a causative relationship in this case between the numerous related species and races, and the number of intersexes observed. Yet this is only an explanation which seems to give most satisfaction, and could not be accepted as final until the matter has been tested by experiment.

More recent experiments point to the same conclusion. What was formerly called *Mermis albicans* by different authors is perhaps a group of morphologically closely related forms. It may be that they are species, or at least races. One of these may perhaps be our *Agamermis decaudata,* which in the adult stage resembles to a high degree the former species and was apparently taken as such by Leidy and other authors. Experiments by T. R. Christie and the writer show that the larvae of this latter species (decaudata), could not be brought to infest other animals than grasshoppers and roaches. Yet this form very much resembles the former, which is said by many writers to parasitize insects of the most various groups, and even snails.

All these facts, it seems, are good evidence that the numerous intersexes observed as normally forthcoming in



INTERSEXES FOUND IN OTHER GROUPS

FIGURE 11. Intersexes have also been observed in several other groups of nematodes. The three left hand figures show respectively the tails of a normal female, a highly intersexual female, and of a normal male of *Enoplus michcalsoni* v. List. (After de Man). This form is a free living marine nematode, very different from the species discussed in this paper. On the right is shown the tail of a highly intersexual female of *Mermis mirabilis*, as described and figured by von Linstow. The male copulatory organs of this female were well developed. *burs musc*, bursal muscle; *♂ ppl*, male papilla of bristle shape; *ptrct mus*, protractor muscle of the spiculum; *rtrct msc*, retractor muscle; *t gl o*, tubular gland outlet, typical of the male; *sp*, spiculum.

our Mermithids are a result of hybridization.

Intersexes in Other Mermithid Species

Ag. decaudata and *Ag. albicans* are far from being the only Mermithid species where intersexes have been observed.

v. Linstow mentions (1903) an intersexual female in his *M. mirabilis*. In this specimen the female sexual organs were well developed, but on the tail end male copulatory organs were to be seen; a male gonad was absent (Figure 11).

Hagmeier observed intersexes in what he terms *Mermis terricola* Hag. Among twelve specimens two were intersexes (Hagmeier calls them hermaphrodites); both had the appearance and size of females; ovaries, uteri, vagina and vulva were well developed; in the uterus of one, ripe eggs were to be seen. But the tail was completely masculine. The spicula of one particularly large specimen were even larger than those of a normal male, but not so strongly, and somewhat irregularly bent, with knot-like thickenings. The sheaths of the spicula and also the long *retractores spiculorum* muscles were present, whereas the bursal muscles were present only in the tail end. The male papillae were typically formed.

The second specimen showed more irregular spicula and only a few male papillae, but here the bursal muscles were fully developed, even also orad of the male sexual opening, but in both cases Hagmeier was unable to find any traces of male gonads.

The same author observed also isolated bursal muscles in some female specimens of his *M. elegans*, *M. albicans* and *M. arsenoides*. Male sexual openings were often observed by him in females of *M. albicans*, but sometimes also in *M. elegans*, *M. arenicola* and *Paramermis fluviatilis*. Unfortunately we do not know the conditions here accurately enough to judge whether the above outlined explanations would fit. Further investigations will have to be

made before the matter will be cleared up. From my own observations I believe that variations similar to those described above for *Ag. decaudata* and related forms may be found in other Mermithid species.

Exactly why the Mermithids produce such an abundance of intersexes, is still unknown, and also why, apparently, only females show intersexual characters. Hitherto no one has observed, or at any rate mentioned, intersexual males in this family. In regard to *Ag. decaudata* it may, however, be mentioned that the number of the papillae on the tail end of the male is extremely variable, as is the arrangement also. It is hard to find even two specimens which are in this regard perfectly alike; also the length and even the form of the tail itself is somewhat variable as well as the length of the spicula (Figure 10).

Intersexes in Free-Living Nematodes

Apart from the family of the Mermithidae intersexes have been seen in very few other nematode genera. Somewhat outstanding in this regard is the genus *Trilobus*, including a number of fresh-water free-living forms. In 1905 (l. c. p. 55) E. von Daday describes a very pronounced case of intersexuality in *Trilobus longus* Leidy (*Trilobus diversi-papillatus* v. Daday.) It was an intersexual female. The ovaries, uteri and vagina of this female were well and normally developed, the vulva had its normal position and eggs were seen within the uteri. But this female had also well developed spicula, and, according to v. Daday, all the preanal accessory organs of the male, consisting of a group of three large, three medium-sized and numerous small preanal papillae. He claims even to have seen a short testis with a short *ductus ejaculatorius*, but apparently not functioning.

More often intersexes have been observed in *Trilobus gracilis* Bastian. Of this species Ditlevsen mentions a female with well developed male papillae, such as characterize the male, but without spicula and gubernacula. Recently Wilhelm Schneider observed two intersexual females of the same species. One had completely developed spicula but no trace of any papillae, the other female showed only three preanal papillae, whereas the spicula apparently were absent. Both specimens had well developed female organs. Dr. N. A. Cobb tells me that he also has observed on several occasions intersexual females in *Trilobus* at Washington, D. C., and Mr. Thorne tells me the same thing for specimens living in fresh water from Utah.

Regarding the causes of the intersexuality in this group of free-living nemas, it is of interest that, at least in *Trilobus gracilis Bastian*, there exist a series of races, genotypes or varieties already mentioned by several authors. I refer in this regard to the paper of Stefanski (1917), and one published by the writer (Steiner, 1919). Undoubtedly we have here a whole series of closely related, but slightly different forms, probably not all known. *Here, too, the observed intersexes may be related with hybridization between these different genotypes.* The above-mentioned *Trilobus longus* is regarded by Micoletzky (1921) as only a variety of *T. gracilis*, but further studies have yet to prove the correctness of this conception.

Intersexes in Marine Free-Living Nemas

J. G. de Man mentioned in 1893 a thoroughly functional female of *Thoracostoma figuratum* Bast. with the spicula, and the gubernaculum of a male and a similar specimen of a female of *Chromadora poecilosoma* de Man.

In 1904 the same author mentions another very interesting case. Of nine specimens of *Enoplus michaelseni* v. Linst. found in algae growing on Gasteropods in the Bay du Torrent, Isle of Londonderry, Canal francais, Antarctic, he observed three females (they were the largest in size), with very pronounced intersexual characters. Two of them had eggs in the uteri; all three had the preanal, ventro-medial cutinized gland outlet of the male and also a

series of fine hairs between this outlet and the anus as in the normal male. In regard to the spicular apparatus, the three specimens represented three transitional grades; in one the apparatus was very similar to that in the normal male. In the third female, however, it was totally different. (See Figure 11.)

Comparing the intersexes of the different species described above, it is very remarkable to note that the different organs involved in the transformation toward the male sex are not progressive. As in the intersex represented in Figure 7, the bursal muscles and the papillae are more developed than in the one sketched in Figure 8, where the spicula are of a more advanced type.

Furthermore, comparing other cases mentioned in this paper regarding this character (f. e., also Figure 6), there are more such irregularities. It seems as if there is no correlation tending to produce gradual stages of development of the different sex organs. Where in one specimen an organ may proceed far along in its transformation, in another it may remain much less developed when compared with other organs involved in the latter transformation. In a recent paper by Goldschmidt (1922), which has just come to my attention, he presents an explanation of similar cases in his broods of *Lymantria dispar*. This explanation may also be applied here. He states that the races of *Lymantria dispar* show a great diversity in the rate of their development, and also in regard to the initiation of differentiation of the various organs which are known to occur at different intervals of time. Inasmuch as these characters are heritable, the hybrids consequently also show differences in this respect. The variations in the rate and size of development of the intersexual organs are a result of these conditions.

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FRESHMEN MATRIMONIAL IDEALS

ROBERT T. HANCE
University of Pennsylvania.

THE characteristics of the person I shall or did marry have been more or less filling the columns of various magazines for the past few years and the mirror has been held up to wife and husband (particularly the latter), most mercilessly. Far better would it be if the holder of the looking glass had been a bit more previous in this occupation in order to save the distressing postmortems and to eliminate the enervating sex triangle plots of the modern middle grade publications. The possible plea of these writers that their stories will bring greater happiness to the readers will not bear the scrutiny of logic, for in them, as in the quack medicine claims, each one may always find symptoms that fit his own case with apparent exactness. To a certain point ignorance is no doubt bliss, but it may also be stupidity and in this case end in disaster.

Believing, contrary to current opinion, that people, given the opportunity to talk are occasionally stimulated to think, the writer has always made openings for a general discussion of matrimonial ideals and desires when such subject matter might naturally crop up in his zoological teaching. Since few men are given to thinking very heavily or exactly on the qualities necessary to complement their own admirable personalities, open discussion of home problems is sure to present new vistas beyond the present requisites of sunrise complexions and a half bushel of more or less artificial hair. The opportunity to talk does gradually bring out opinions and the interest soon becomes such that the students forget to talk for effect and begin to put into words what they have never really considered concretely.

In a recent examination the following question was given to get some written statement on this subject from a large number of college freshmen:

> The aims of genetics and eugenics have been elaborated in discussions and in your readings in the books of Guyer and Conklin and by this time you should have some appreciation of what can be done in the way of perfecting all forms of life through proper selection and breeding. Obviously it is impractical, not to say impossible, to apply the same rigorous methods of selection and mating to man as is done with the lower organisms. Laws along these lines must consequently be ineffective and the greatest hope of improving the human race is through a comprehensive educational program.
>
> The importance of the proper selection of mates is great, both as regards the possibilities of the future generations and as regards the happiness of the individuals concerned. It is important that men and women have a clear conception of the type of person with whom they will be most likely to live in harmony.
>
> Write an exposition on "What characteristics I believe to be necessary in the person I shall some day marry." Discuss this question from the point of view of individual as well as racial happiness and success as fully as your information permits.

There is little reason to doubt the sincerity of the writers, for it was very easy to recognize an answer written to impress the reviewer. The answers have been strung together into a continuous tale and follow.

The Ideal Husband

The famous admonition, "Women and children first," requires that we consider the attitudes of the Co-eds on matrimonial ideals before we do those of the men. General experience indicates that on the whole the women frequently have a bit more concrete, definite and worthwhile ideas on the subject of the qualifications of their mates, suggesting that they probably have given the matter more attention. Their statements tend to be, I think, a bit less

stereotyped than those of the men, who are apt to have acquired their eugenics pretty largely for a definite occasion.

As can well be foretold, the requirements cover relatively few general topics though the variations under each of these are as many as there are writers. Pre-marriage frankness, and physical and mental characteristics in relation to personal tastes and to the production of fit children form the central theme of most of the records. The latter is the more remarkable in that in these days of fractional offspring per intellectual capita most of the writers seem to be figuring in terms of the whole number, and even in some instances in the plural.

There seems to be some real appreciation of the value of physical appearance as an index to health and it is seldom that the valuation is wrongly stressed on the "beauty" side alone. Throughout the papers run expressions in regard to physical well being and similar basic desires, differing only in terminology. To suit our Co-eds a man must be of "good appearance," "physically sound," must possess "strength and proportion," "cleanliness," and alas for someone's ideals, "he must be physically perfect." Considerable stress is laid upon cleanliness which may give some pause for thought. One logically points out that "sickness interferes with a pleasing personality."

Possibly with the physical traits might be indicated the realization of some of the difficulties of interracial alliances. These expressions naturally come mostly from the Jewish girls. An element of patriotism seems to influence some in arguing against foreign matches. One girl maintains that her children could not be pure-blooded Americans if the father was a foreigner. It might be of some interest to have her definition of such homozygous American stock and also that of the person whose ideal is a "real American of English, French, or Spanish descent."

The demands in the intellectual field are just as rigorous as in the physical. The male mate must possess refinement, have personality, be broad-minded, be intellectually superior, must "be of the sort that I would be willing to have my friends meet," and lastly and probably most important, "he must possess real understanding which leads to true companionship." One girl has clearly seen that there must be mutual concessions in order that understanding and real companionship, with the resulting great affection, will reign supreme.

Hybrid Creeds

Some anticipation of the difficulties caused by crossing creeds leads a few to foreswear matches involving such possibilities. While religion has been mentioned by a very few still, it is a very active part of one girl's ideal, who must qualify, according to her terse statement, as "healthy, clean, white and a desciple and lover of Jesus Christ, our Lord."

The increasing expectation of premarital discussions and frankness cannot fail to produce desirable results. We cannot help but feel that the writer of the following lines is on the right track and hope that she will meet her match "who must be able to talk frankly of marriage and its relations in order to have the right understanding. If he cannot, he has false modesty which is ignorance." Incidentally there is to be no condoning of wild oat farming, nor yet of intemperance of any sort.

It is a pleasure to note that a few girls—but none of the boys—know that the most essential mental characteristic needed to bridge over many of life's rough places is a sense of humor. If one can laugh there is at least small opportunity for crying unless, of course, one possesses a Celtic gene, when it is possible to do both at once and enjoy it greatly.

"The desire of all women is to have healthy children" though possibly open to debate on at least one score, still expresses an issue that is not dodged by any. Unless they fall down when

it comes their turn to face the reality, we may expect more from them than the traditional portion of an offspring statistically allotted to each college graduate.

Among minor desires falls the hope that the next generation will be "curly headed" so that they will not be afflicted with the female curse of straight hair. The man of one pair must be "strong enough to hold up his end of the argument, otherwise he'll be apt to get the worst of it."

In reviewing the statement of the women, I think, that they all show desires that are apt to make for stable happiness. The women seem willing and anxious wholly to do their part in making mutual concessions and to take up the increased burdens. Selfishness—a characteristic believed to be dominant in a class of women today—appears in only one instance and for the possible man's sake we hope with the writer that she'll "never be foolish enough to marry anybody" for if she did she has in mind more restrictions than a League of Nations.

The Ideal Wife

In turning our attention to the hopes of the males, we find very much the same ideals running through their discussions. Most of them really seem to believe that beauty is as beauty does and so long as a girl is free from abnormalities more cannot be expected. A reviewer may have just a bit of skepticism on this point and feel that on man more correctly expresses the usual instinct when he claims that while the male ideal need not be good looking, still that is a very nice characteristic to have. At least some sages are to be graduated, for out of the mouths of babes comes the information that "looks make little or no difference although the saying goes 'if you want to know your wife at fifty, look at her mother now.'"

We again hope that writers are sincere in desiring women of mental attainments equal to their own. Many want mates to balance their peculiarities —mates who can take things as they come—a few require parlor tricks or a mate who will in general "speak my language," and lastly, to counterbalance the sense of humor desired by the women, we have from the men the expressed hope for a girl with common sense. Whether we may classify as a mental attribute the necessity of the girl's thinking, "I am the best man this side of heaven," is doubtful.

Ability to manage a home and to cook is the materialistic expectation of many and to this one man adds that his woman must have ambition to get up in the morning and dress. Companionship is realized to depend upon common interests and congeniality and finds able expression in the phrase, "harmony is a good thing in any enterprise."

The mixing of races is believed to be dangerous to happiness by the Jews. Religion is very frequently mentioned as a good thing to look out for in matrimonial planning. There seems to be some agreement on the proposition that "religion keeps men together, but ruins all aims of genetics and eugenics," but the chap who wants a "Christian—not a Roman Catholic"—might strike fire in some circles.

We can see a very fair tendency in the men to pass up their time-honored right to distribute wild oats in such statements that "she must be healthy and fairly young and like Caesar's wife 'above suspicion.' It is unjust for a man to expect more than he gives." Or again "the musculine sex seems to be much interested in finding a mate with all the characteristics that will help to elevate their children, but how is it possible when the father is generally the one who is pulling down the moral standard of mankind daily."

Children are expected and wanted and the value of healthy parents is appreciated. One man goes the Eugenists one better by insisting on knowing the girl's "family skeleton." One optimistic pessimist concludes that the standards set auger bachelorhood for him.

Through what has just been read runs, what I really believe to be, an honest expression of opinions which seem to be basically good and may indicate that the reason for the usual success of college matches lies in the clearheadedness of the participants. It is a matter of opinion which sex as here recorded is better versed in the requirements of dual happiness, or whether the honors are not evenly divided. That many of the ideals will be altered in the years preceeding their realization is fully to be expected, but if only a portion of these hopes materialize we have a fair basis for a satisfactory home life. Consideration, unselfishness, a sense of humor, with its running mate common sense, can lead to little else than affection. These requisities the college freshmen seem to glimpse more or less clearly and it is encouraging.

At any rate we can gather a composite picture of the ideal college mate from the foregoing, but we must admit that all the tragedy was not penned by Shakespeare for the lament arises in the words of the victim "this dear friend, is my ideal and I think that I have found her. But—last July she announced her engagement to another, so my house of cards has fallen." But on with the dance—another concludes with the exclamation—"now let me look for that woman"!

Hygienic Marriage Laws

Das Aertzliche Heiratszeugnis, Seine Wissenschaftlichen und Praktischen zur Frauenkunde und Eugenetik No. 2. Pp. 72. Leipzig, Verlag von Curt Kabitsch, 1921.

The desirability of having applicants for a marriage license present a certificate of medical examination has often been urged, and has been given expression in bills offered at one time or another in almost every state legislature of the Union. Some states have actually adopted such a law, but the administration of these statutes has not given satisfaction to either friends or enemies of the measure. The principles underlying such legislation are discussed from almost every point of view, by eight specialists whose addresses are assembled in the present book.

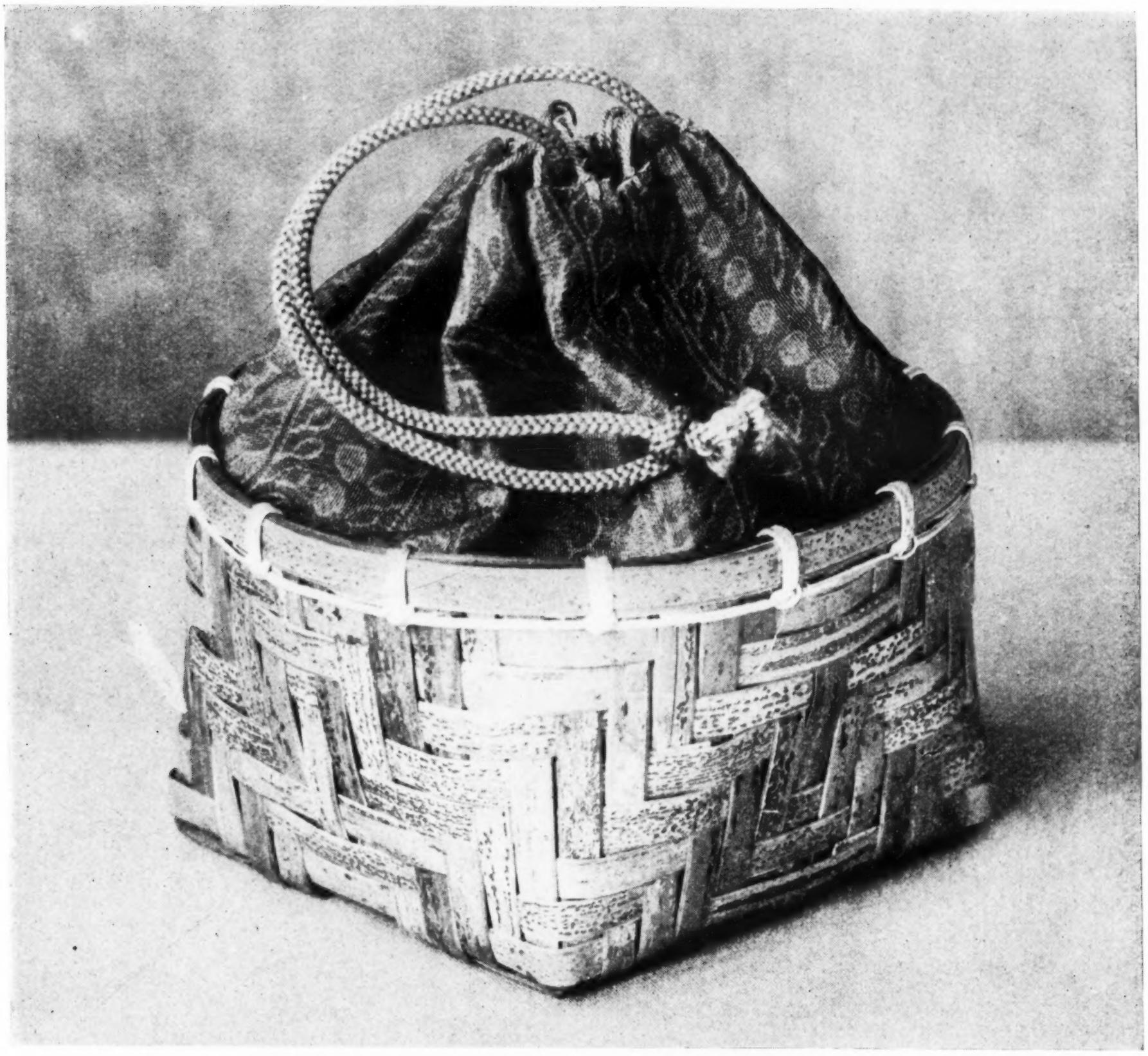
A law providing for medical examination before marriage is frequently described as eugenic; it is, however, largely hygienic, although two classes of conditions are naturally dealt with, the inheritable and the infectious. In the United States the expense is charged to the applicant, but the German students hold that the state should provide the examination without cost.

Nearly all of the German writers here represented are opposed more or less strongly to the compulsory medical examination before marriage. The grounds are exceedingly various, but the lack of competent examiners (especially of women physicians) is one of the most serious. Dr. Hirsch, in the concluding paper of the series, makes a strong plea for the compulsory examination but holds that it should not be associated with any prohibition of marriage. The candidates for matrimony should be required to know their own condition; then it must be left to them (save in exceptional cases of insanity, already covered by law) to decide whether or not they are fit to marry.—*P. P.*

AN ORNAMENTAL PARASITE

RAISED BY THE JAPANESE TO DECORATE BAMBOO CULMS

TYOZABURO TANAKA
United States Department of Agriculture.



BASKET DECORATED WITH ARTIFICIAL FUNGUS INOCULATIONS

FIGURE 12. Rather an unusual industry is carried on by the Japanese to maintain the supply of fungus-infected bamboo culms that are used in making basketry and other ornamental objects. Different species of fungi produce different shapes and colors of spots on bamboo. The varieties that are most in demand have recognized "trade names," and the fungi producing them are propagated artificially. Photograph by E. L. Crandall.

PARASITES of economic or artistic importance tend to raise their class from the ill repute they commonly enjoy. In the West the mistletoe is cherished for its prettiness and Yuletide associations; the Eastern peoples cultivate parasitic fungi because they ornament the bamboo culms on which they grow. The beauty thus obtained has economic value, for the

bamboos are used in making baskets, flower pots, chop-sticks, utensils and other objects.

Different fungi produce different shades and types of ornamentation. The best known among the culm-infecting fungi is *Miyoshia fusispora* Kawam which attacks the bamboo *Arundinaria Narihira*. The large oblong patches of various shades, formed by this fungus, produce an ornamental effect for which such bamboos are highly valued. The natural habit of the fungus is complemented by inoculations artificially made to give the patches their right position and shape. The infected culms are cut down at the proper time and patiently polished to enhance their appearance. A good *Miyoshia* spotted bamboo often will cost several hundred yen (about two hundred dollars) when it is worked out as an attractive flower base or Chadogu (various utensils used in the tea ceremony).

Fungi decorating their hosts in manner different from that of *Miyoshia* are also widely cultivated. Small dark-colored spots caused by *Melanconium Shiraianum* Syd., *Didymobtryum Kusanoi* P. Henn., or *Eutypa Kusanoi* P. Henn, produce other ornamental effects on bamboo culms. The first species has been known since ancient times as *Také no sabi* or the rust of bamboo culm.

According to Sydow (Hedwigia, 1899, p. 144), *Melanconium Shiraianum* forms dense shiny black spots one-half a millimeter in length, taking an elliptic form on the culms of certain kinds of bamboo collected by Professor Shiria at Komaba, who identified this as the well-known *Také no sabi*.

The basket here illustrated was secured by Dr. W. T. Swingle in Japan in 1898. An examination by Miss Vera K. Charles, assistant mycologist of the Bureau of Plant Industry, United States Department of Agriculture, showed the fungus on this basket to be incompletely developed. Its appearance suggests Munkiella, which is the perfect stage of *Melanconium shiraianum*. The identification could not be made positive, however, owing to the immaturity of the fungus, development having probably been arrested by the treatment received in the preparation of the material for weaving.

A Textbook of Embryology

LEHRBUCH DER ENTWICKLUNGSGESCHICHTE, by DR. HERMANN TRIEPEL of Breslau. Two revised volumes. Pp. 210; 173 illustrations. $1.90. Leipzig, George Thieme, 1922.

In a compact but clear style, Dr. Triepel covers the ground belonging to an elementary course in embryology. While most of his data are drawn from the comparative study of various classes of animals, he deals adequately with man, and his material on the phenomena preceding zygosis is ample. The illustrations, all of them from drawings and mostly the work of Helene Limpricht, are particularly noteworthy.—*P. P.*

AGE AND AREA

A REVIEW OF J. C. WILLIS' THEORY OF THE ORIGIN OF SPECIES

HUGO DE VRIES
Lunteren, Holland

IN a series of articles, published during the last twenty years, J. C. Willis has tried to show that the dispersal of plants is governed by general laws and independent of so-called adaptations, or of any kind of advantageous response to local conditions. The main factor of distribution is age, a cause which works in the same manner on all plants. The rate of expansion of area is a fair measure of age. The most widely distributed genera and species in every family are to be considered as the oldest within that group, and, taken broadly, the remaining ones must be progressively younger, the smaller the area they occupy. Number of species usually goes parallel to geographical area, and therefore the genera which are richest in species will also, as a rule, be the oldest of their group. Senecio, with 1500 species, has been the source whence the family of the Compositae has been developed. Astragalus with 1600 species is at the bottom of the papilionaceous plants and other large genera could easily be added.

Of course, age in itself is not the cause of distribution; it only allows the time for this process. Moreover, when one considers single species, as has been done most generally in plant-geography up to this time, the influence of adaptations, of dispersal methods and so forth may easily lead to the conception of special laws for different forms. Therefore it is necessary to study averages, instead of single cases. In doing so it is found that the resultant effect of the active factors, biological as well as ecological, is very uniform and almost wholly the same for different families or for the members of different floras. Considering long periods of time and taking the species in small groups of allied forms (e. g. of 10-12 each), in order to calculate averages, one finds that all plants spread at a fairly average rate.

The author has now collected his results in a book, entitled *Age and Area, A Study in Geographical Distribution and Origin of Species* (Cambridge, 1922, p.p. 259). The discussion of his law is founded here upon a broad basis, combining the results of the investigation of numerous local floras and comparing them on all sides with previous views. Many objections and many criticisms had already been published by different authors and they are now dealt with in such a way as to insure the validity and the general applicability of the main law. Confirmations have also been numerous and among these I might cite the work of J. Small upon the evolution of the Compositae. In a chapter on this group, inserted in Willis' book (pp. 118-136), Small shows that the pedigree of this family, as derived from the morphological characters of the stigma and the stamens and from the study of the fossil fruits found in the deposits of the tertiary period, wholly agrees with the predictions which can be made from Willis' law. Expansion of area, and number of species, if calculated in averages for the different tribes and subtribes, are almost exactly parallel to the ages derived for them from systematical and palaeontological data.

The Flora of Ceylon

Willis started his statistical researches with a study of the flora of Ceylon, and afterwards applied his results to

that of other oceanic islands and of other more or less isolated regions, finally covering the flora of the whole world. For this reason it seems desirable to consider the island of Ceylon here also, in the first place. Such a process will at once put the meaning of the general law in a clear light.

The flora of Ceylon embraces 2809 species of Angiosperms, of which 809 are endemic to the island. Of these latter about 200 are confined to very small areas and about half of these occur upon the tops of single mountains or on small groups of mountains. There are 1027 genera, of which twenty-three are confined to Ceylon, and among the 146 families this is the case with six. Most of the endemic genera are represented by one species only, four by two or three and only two (Doona and Stemonoporus) by a larger number. The endemic types are well marked Linnean species and as such sharply distinguished from their nearest allies, but a comparison of their characters does not reveal any qualities which could be regarded as useful under the conditions of their localities. On the contrary, it is evident that they do not surpass their more widely distributed allies in this respect. Moreover, many of the endemics occur as a very few individuals, say only a dozen or more, and the places where they can thrive are often so small that it is obvious that they can never have been much more numerous.

These facts lead to the conclusion that the endemics are not, as a rule, the remnants of forms which previously had a wider distribution, but which are now gradually dying out. In the temperate regions of the northern hemisphere there are a great many endemics of this kind, and they are usually designated by the name of relics. They are the survivors of species which were widely spread during the tertiary period, as has been proved in many instances by the study of their fossil remains. But there is no good reason to apply these results to the Ceylon endemics, nor to those of tropical and subtropical regions in general. Moreover, the northern relics are rare as compared with these. North America has only about 400 such forms, whereas the small island of Ceylon has 800 endemics, as has already been stated. Brazil has 12,000 such species, New Zealand and many other oceanic islands are even richer in them, when areas of the same size are compared. The real relics may be estimated at one or two per cent of all the endemics and therefore they cannot be considered as indicating the general condition of the forms of this group.

Willis proposes the conception that most of the endemics of Ceylon and of other similar regions are, quite on the contrary, the youngest members of their flora. They must have originated on the same spots where they are found now. And, since most of them have the same means of dispersal as their more common allies, it seems evident that if time were allowed, they would spread like these. The smallness of their area can therefore only be explained in a satisfactory way by assuming that they have not had the time to gain a larger territory. As soon as this main point is conceded, it is obvious that the size of the territory occupied by an endemic species is to be considered as the result of the lapse of time during which it has been able to spread. Or in general terms that the area covered is a measure of the relative age of the species under consideration. Age goes parallel to area, and this, condensed into its smallest form, is the meaning of the phrase, *Age and Area*.

Of course, this rule cannot be restricted, either to the plants of Ceylon or, on the other hand, to endemics only. If true, it must embrace all species of organisms and all geographical regions. It must be the main law which governs the geological and geographical evolution of the whole living world. Distribution must go on everywhere on the same general lines, it must be

independent of special organizations or so-called adaptations.

In following this discussion, many readers will object that there are too many single instances which do not seem to be in accordance with this new law. In order to reply to this objection, Willis has introduced his principle of averages, or what we might call his statistical method. A general law can only be extracted from the study of individual cases, if these are combined in sufficient numbers to smooth the effects of their special features. Age and area should not be used as a comparison of single cases, but for small groups of allied forms, such as the species of a genus, the genera of a tribe or the tribes of a family. Experience has proved that averages for groups of about ten such types suffice to eliminate the effects of most of the deviations. Whenever possible, groups of fifteen to twenty species should be preferred. In doing so the method may be extended to biological or ecological groups of plants as well as to systematical ones.

When one considers such groups and compares them with other related sections, the effects of age will show clearly, because the other factors in dispersal will either be pulling the same way upon all, or will cancel one another by pulling in different directions. Age, however, is always pulling alike upon all species. The greater the number of allied forms taken, and the greater the length of time considered, the more clearly will the effects of age show.

In applying this statistical method to the flora of Ceylon, one has to compare two main lines of geographical facts. One of them relates to the probable age of the species, the other to their present distribution on the island. Three main divisions are proposed, one containing the endemic species, the second those confined to Ceylon and Peninsular India, and the third the forms of wider distribution. The distribution on the island itself is derived from the data given in *Flora of Ceylon,* by Trimen and Hooker. These authors divide all species into six classes, viz.: 1, very common; 2, common; 3, rather common; 4, rather rare; 5, rare; and 6, very rare. The number of species belonging to each of these classes is then multiplied with the factor indicating their degree of rarity, and this is done for each of the three groups of different dispersal. From these figures averages may be calculated, which give the degree of rarity for any group under consideration. In this way Willis finds.

	No. of Species	*Rarity.*
Mean rarity of all species...	2,809	3.5
Species of wide distribution..	1,508	3.0
Of Ceylon and Peninsular India	492	3.5
Species endemic to Ceylon...	809	4.3
Species of all the 23 endemic genera.	52	4.5
Species of Doona (endemic).	11	4.6
Species of Stemonoporus (endemic)	15	5.4

From this table we see that the species of widest distribution are the commonest, that those of Ceylon and Peninsular India have just the mean degree of rarity, whereas the endemics are relatively rare. The species of the endemic genera, and especially of the only two genera which are rich in endemic species, are the rarest of all on the island. Further tables, which cannot be reproduced here, show that the different families of this flora behave in the same manner, showing that no one family has any particular advantage over another. The same rule prevails for the genera and even for ecological groups of species. Everywhere the order of rarity within the island is parallel to the degree of the distribution outside of it.

Confirmation of this law was then obtained by working out the flora of New Zealand, of the Hawaiian archipelago and of other oceanic islands after the same method. The orchids of Jamaica, Callitris, a coniferous species of Australia, the ferns of New

Zealand and many other groups gave the same result, showing that the law is quite general. Other authors have contributed analogous data for the grasses of Australia, for the endemics of the Bahama Islands and other cases. Everywhere the statistical method, just described, conduces to the same conclusions.

In stating the rule in a general way, some restrictions will, of course, be found to be necessary. For this reason I wish to quote the most recent expression of these as given by the author: "The area occupied at any given time, in any given country, by any group of allied species at least ten in number depends chiefly, so long as conditions remain reasonably constant, upon the ages of the species of that group in that country, but may be enormously modified by the presence of barriers such as seas, rivers, mountains, changes of climate from one region to the next, or other ecological boundaries, and the like, also by the action of man, and by other causes."

The main point in this contention is, that the species have to be considered in small groups of allied forms. If single species are studied, the distribution will of course depend upon many factors which, however, cancel one another as soon as the statistical method is applied to them. Among these factors the most prominent are given by the means of dispersal, acclimatisation, suitability to the society of plants in which a species may find itself, barriers of all kinds, whether physical, climatic or ecological, individual habit of the species itself, and so on. But these factors will be different for the individual species, whereas age works on all of them in the same sense.

Or in other words, while the possession of a good mechanism for dispersal may be of great advantage to a plant, especially in reaching areas that are only a small distance away, it is by no means essential for world-wide distribution.

Origin of Species and Natural Selection

On the basis of these statistical results the theory of the origin of species by means of natural selection of infinitesimal variations is subjected to a severe criticism. As a rule, the rate of dispersion of new species is independent of their special organizations, since it is the same for all of them. In the largest number of endemic species there are simply no adaptations to the local conditions. The new forms inherit their suitability to their environment from their ancestors, without any appreciable change or improvement. The systematical characters, which constitute them as good Linnean species, do not show any regular relation to their struggle for life. Considered from a biological point of view these new qualities are of very secondary importance.

From these considerations some very valuable deductions may be derived. It goes without saying that any new forms which should not, from the very beginning, be sufficiently adapted to the prevailing conditions of life, will soon be wiped out. But whenever the adaptation is the same as that of the ancestors, the chance of survival will also be the same. The new forms will develop and spread beside the older ones, and according to the same general law. There is no reason for assuming a further competition between the species, even if the struggle be sharp between the individuals themselves. The struggle for life, which took so prominent a place in the older theories concerning the evolution of the species, seems to be reduced to the very first period after their origin. New forms have not to conquer their ancestors in order to supplant them, nor to extirpate them in order to secure their places in the flora for themselves. The older species may simply continue their spreading beside their derivatives. Some of them may, of course, die out in the process, but this will be rather an ex-

ception. We are not obliged to regard a new species as coming into existence at the expense of its ancestors, as was assumed under the theory of natural selection. The areas now occupied are large enough to offer sufficient room to newcomers, provided these are as well suited to the obtaining local conditions as the previous inhabitants.

If the appearance of a new form does not imply the disappearance of its ancestors, the whole, or at least a great part of the family tree of existing species should still be surviving. It is commonly assumed that such pedigrees are often only incompletely represented by the existing forms and that many links have disappeared during the geological periods. Discontinuity in a pedigree could always be easily explained in this way. The conclusions of Willis, however, no longer allow the constant use of this method. If, as a rule, species survive beside the new ones evolved from them, there is no good reason to assume gaps of any importance between the members of any given family. The pedigree of the whole should still be represented in a practically continuous way by the totality of the living species. This is a simple and clear principle, which may free the systematists from superfluous hypotheses and at the same time make their conclusions concerning the affinities of the genera and species within a family more convincing and more reliable.

The Evolution of Species

Species are thus assumed to have evolved from one another by means of small steps and not by the slow and gradual accumulation of infinitesimal variations. It is now generally conceded that this latter theory can by no means explain the first beginning of the process. This view supposed the selection to take place as a result of some slight advantageous response to surrounding conditions. But the first steps cannot have had such a decisive degree of utility, even if the whole specific difference could be shown to possess it. In the differentiation of new species the steps must therefore have been of some definite importance. But how large have they been? This question has, at the present time, quite another meaning than it had half a century ago. We are now accustomed to consider the qualities of organisms as built up of units, which are usually designed as hereditary factors or simply as factors. In experimental work we rarely know whether a factor is really simple or still a compound entity, since in so many cases factors originally assumed as simple have been split up into minor units in the course of further researches. Leaving this difficulty aside, the question remains whether the steps which have produced the existing species are to be considered as involving each a single factor or a small group of such.

Willis replies that such changes may at times occur of the necessary size to give rise at once to Linnean species. The elementary species of *Draba verna* and of numerous other plants, described by Jordan, are often looked upon as constituting the steps by which species have been evolved in nature. In order to get real Linnean species we could suppose large numbers of the small species of *Draba verna* to die out, since the differences between the remaining ones would then evidently increase, and might easily reach the degree necessary for them to be admitted as good species. But there is no good reason for the theory of dying out, and the discoveries of Willis show such a process to be rather an exception in nature than a general rule. The Jordanian varieties show the same phenomena of dispersal as do ordinary Linnean species. Often they occupy as large areas, while they still remain true-breeding, and show no sign of variation. Jordan himself has always described them as members of well known good species, not as intermediates between such. Evidently they do not constitute the steps which previously might have linked existing spe-

cies, nor those which would normally lead to the origin of new species. From this we must conclude that mutations giving rise to new forms in nature may vary in size in the same way and in the same degree. Some of them will produce Jordanian types, but others will give Linnean species. It seems that this is the general rule, though it must be conceded that in exceptional cases the dying out of intermediates may have contributed to the now existing differences. And if we consider the probable connections between the families themselves, and their evolution during the primary and secondary geological periods, it is at once clear that the disappearance of linking types must have played more than a subordinate role.

Therefore we must conclude that, as a rule, or at least in a vast majority of instances, species have been derived from one another by single steps, embracing the whole of the differences indicated by the systematical diagnoses. The hereditary factors must change in small groups, say of two or three or some few more units. They must be assumed to be connected with one another, and not as free as the varietal factors, studied in hybridizing, usually prove to be. In this respect it may be of interest to cite the experimental mutations of the species of Oenothera. Here also the factors do not, as a rule, change one by one, but almost always in small groups. Every new type is distinguished from its direct ancestor by quite a number of characters, giving a diagnosis of the same size as those of the wild species themselves. In the beginning these differences have been looked upon as units, afterwards as compound factors, and of late an analysis has been attempted, in order to separate the true constituent units. But this study has encountered, until now, the same difficulties as are opposed to a factorial analysis of specific diagnoses in general. In the meantime we must be contented with acknowledging the fact that the directly observed mutations may, at least in some cases, be of the same nature as must be assumed for the origin of wild species on the basis of Willis' theory.

The Origin of Genera

We may go one step further and consider the probable origin of genera. Have these been evolved by a series of steps and by the disappearance of the intermediate types? Or is their method of development governed by the same laws as that of the species? It seems probable that at least in many cases the response to the last question must be affirmative, since the assumed disappearance would include such a vast amount of intermediate types as is hardly compatible with the general laws of distribution. But there is another fact which may be adduced here. I mean the frequency of monotypic and ditypic genera, including only one or two species. They are very numerous, over thirty-eight per cent of the genera of the world containing only one species each, and about thirteen per cent containing only two. Monotypes and ditypes together constitute, therefore, more than half of all systematical genera. Genera with three, four or more species than follow in diminishing numbers and very large genera are very rare in almost every family. From this consideration we may conclude that there is no real difference between genera and species, except in size, and that therefore the origin of the first has been governed by the same general laws as that of the latter.

The same analogy that connects Jordanian with Linnean species is thus connecting species and genera also. The new law, that age goes parallel to area, and that the method of evolution and distribution have been, in the main, the same in all branches of the animal and vegetable kingdom, seems to be the principle which must direct all further researches in the geography as well as in the genealogy of the living world.

BOTTLE GRAFTING

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It is well known that plant hybrids are usually unable to breed true when propagated by seed, but fortunately, in the majority of cases a desirable plant can be multiplied by vegetative means. Thus most of our fruit trees and our various named varieties of roses, tulips, dahlias, potatoes and many other plants are kept true to type by the processes of budding, grafting or propagating by cuttings or by vegetative means of reproduction such as bulbs, roots and tubers. By the chance union of Mendelian factors in hybridization many combinations of characters are possible, and it is usually the rare combinations which give us our choicest varieties. These choice varieties are usually highly complex hybrids, and in consequence the mixture of factors which they contain segregate and produce new combinations in the formation of pollen and egg cells. This is the reason that they cannot breed true by seed. Seedless methods of multiplication are of value not only to the practical plant grower but to the plant geneticist as well, who frequently wishes to carry over individual plants from one season to the next in order to use them in his breeding experiments.

In our work with the Jimson Weed, for example, there are many forms which, when propagated by seed, give rise to only a small percentage of offspring like the parental type. Others like our Haploid and Triploid Daturas (with one-half and one and one-half times the normal number of chromosomes respectively) cannot ordinarily be expected to produce any seedlings like themselves, and therefore can be carried over only by vegetative propagation. Grafting has been found rather difficult with material which has been checked in its vegetative growth both by fruiting and by the low temperature encountered toward the end of the growing season. If the grafted plants were kept too moist they would tend to rot. If the surrounding air were not moist enough, they would dry out and no union would be formed between scion and stock.

To obviate the difficulties which have been enumerated the idea occurred to us of keeping the scion supplied with water during the formation of callus by immersing the base of the scion in a bottle of water. Such bottle grafts have been eminently successful and we are now able to graft readily slow growing forms with which we were formerly rarely successful. We have grafted even albino seedlings which had not yet shown any true leaves. The process in bottle grafting is relatively simple. Almost any method of grafting can be used, provided the base of the scion is left free for immersion in a bottle of water. The conducting foot should be long enough and project sufficiently to prevent capillary water from wetting the place of junction. We have usually cut the end of the stock to form a wedge which has been inserted into a cleft in the scion. In about two weeks a union is made and the wrapping of raffia may be removed.

The accompanying photograph (Fig. 1?) shows various stages in bottle grafting. At the left is a purple-stemmed stock upon which a green-stemmed scion has just been grafted. The base of the latter may be seen inserted in a small bottle of water which is held to a stake by a rubber band. The pot in the middle contains a stock and scion which were similarly grafted

JIMSON WEED PROPAGATED BY "BOTTLE GRAFTING"

FIGURE 13. On the left is shown a "bottle graft" in position, with the end of the scion projecting and immersed in a small bottle of water. This prevents the scion from wilting before union with the stock occurs. On the right is shown a completed graft in which the end of the scion has not yet been trimmed off. On the plant in the center the projection has been removed so that the point of junction will heal over smoothly. "Bottle grafting" is really a modification of the older method of inarching in which two living plants are placed side by side and grafted together.

at an earlier date. The base of the scion which acted as a feedpipe for water has been removed and a single band of raffia protects the union and prevents it breaking at the joint before it has been strengthened by the formation of woody tissue. The pot at the right contains a green-stemmed stock upon which has been grafted a purple-stemmed scion. The foot of the latter which connected with the bottle has not yet been removed and may be seen as a small projection on the left.

Obviously bottle grafting is merely a modification of inarching or the grafting together of two plants which are growing side by side. Doubtless this method has been used by others, since it is a natural means of obviating the difficulties encountered in attempting to graft slow-growing scions. It is not mentioned, however, in Bailey's *Standard Cyclopedia of Horticulture*, nor is the method known to a number of horticulturalists and botanists with whom we have discussed the method. We are publishing this brief note, therefore, to call attention to a method which we believe may be of considerable use to plant geneticists in keeping alive exceptional breeding material.

Blood Tells Again

The Colorado Endurance Ride takes place each year to stimulate interest in the breeding and use of better saddle horses. It is a gruelling test of endurance, which only a fine horse can survive. The distance covered is about three hundred miles. The contest lasts five consecutive days, the daily course averaging about sixty miles. Each horse is required to carry 225 pounds.

It is an interesting fact that this contest, like the races for speed, goes to the pure-bred horse. In former years scrub horses have been allowed to enter, but in 1923 they are barred for the reasons given below:

"A provision adopted for the Colorado Ride of 1923, which has always pertained in the East but was not heretofore prescribed in the West, is that which requires that a competing horse be at least a half-bred of some recognized breed; in other words, his sire or dam must be a pure bred.

The Sponsors' Committee when considering this matter in 1922 recognized fully that, from many standpoints, it was a sheer waste of time to permit the entry of horses of unknown breeding; for even assuming the possibility that such a horse could win, no useful information would be derived from his performance, inasmuch as one would have no clew as to how to reproduce him. However, it was deemed wise to open the entries to scrub horses for one year, in order to render it abundantly clear to ranchmen that the proper type of blood horse excels the horse of no breeding at any task, whether it be running at high speed, or carrying weight for long distances. This having now been satisfactorily demonstrated, entries have been restricted to horses of known breeding, from whose performance useful information may be derived.

The Colorado Ride, while being in terms identical with that conducted in the East, will in fact be a very much more severe ordeal, due to the circumstance that on several days of the Ride the mid-day halt will be between 1,500 and 2,000 feet higher than the start on two more days it will be more than 1,000 feet lower. These heavy gradients, if negotiated successfully and with approximately equal speed, will unquestionably make a better showing for the Colorado horses."—*The Remount*. Vol. 4, No. 1, pp. 13 and 14.

THE STORY OF THE MAIZE PLANT[1]

A Review

THE story of the maize plant is a comprehensive title and the subject is encompassed in a small volume of 247 pages, including a bibliography and index. The motive which actuated the compilation of material for this story is based, according to the preface, "on numerous inquiries for specific information about the maize plant received by the author in the course of four or five years." Being a morphologist it is not surprising that the inquiries he received should relate largely to morphological features and this doubtless accounts for the emphasis placed on morphology in the present volume. The geneticists almost certainly will feel that their investigational field has been given scant treatment, but this feeling may be due somewhat to prejudice and after all the brevity with which genetics is treated may prove a blessing.

There can be no question as to the intensely interesting character of the morphological problems found in maize and the contributions on these, which largely are a reassembling of the author's previous works, are welcome and, combined in one volume, may be said to fill a long-felt need.

The inclusion of material other than morphology was doubtless at the insistence of the editorial committee prompted perhaps by the desire for an appealing general title and the result, as might have been anticipated, has been to dilute a good morphological treatise with irrelevant and often archaic ideas. The chapters on tillage will scarcely meet the approval of the agronomists and the incongruity of presenting descriptions of corn planters and harvesters between the detailed histological accounts of the root system and floral organs will be patent to all. One misses the familiar drawings of the farm implements discussed and it is to be hoped that this oversight will be corrected in later editions.

A comprehensive bibliography is appended which may be as good as those in many similar publications, but a hasty perusal of the titles affords little clue as to what influenced the choice of references. Throughout the text it seems to have been largely a matter of chance whether or not the sources of information were cited, though an exception has been made with the historical references where it was obvious that the author could not have made the original contributions. Perhaps the most conspicuous omission is the failure to refer to the work of Hayes and East in the extended discussion of the floury-corneuos crosses.

The arrangement, which should not be charged to the author alone, being also a responsibility of the editors, seems capable of improvement and much reference back and forth throughout the text as well as some needless repetition seems avoidable.

The author is to be congratulated on having receded somewhat from the dogmatic utterances of his technical papers—a hopeful sign that increasing experience will bring about true scientific openmindedness. It is interesting to note, however, that he still feels that observations based on other than embryological characters are superficial and promise only a "precarious base for philosophic consideration."

There are three minor departures from accepted nomenclature. Thus the author throughout capitalizes the specific name of Zea (mays), places an accent on the final "e" in teosinte and

[1] WEATHERWAX, PAUL. The Story of the Maize Plant. University of Chicago Science Series. 247 pages. 174 figures. 2 colored plates. University of Chicago Press, March, 1923.

designates the grass family "Gramineae."

It is well to note that the range of teosinte is given as including Central America. This may seem a minor point, but taken in connection with the area covered by the civilization of the Mayas, it is extremely important to know whether this ancestor of maize existed in their terrtitory. For several years past we have been endeavoring to verify the occurrence of Euchlaena as a wild plant in Central America, but as yet these efforts have been abortive. Until definite information is obtained it seems undesirable to extend the range of this species to include Central America. (See Hitchcock, A. S., *Jour. Wash. Acad. Sci.*, Vol. 12, No. 8, P. 205.)

It is apparent that the author still fails to appreciate the true nature of prophylla. One harldy would have expected a morphologist to overlook the fact that two buds often are developed in the axil of the prophyllum of maize and doubtless the vestiges of these buds always are present. This is all the more surprising in view of the author's predilection for vestigial organs.

The absence of satisfactory morphological evidence of buds at the upper nodes does not seem to suggest to the author the possibility that such buds do not exist. This failure to abide by the morphological rules of his own making is evidenced elsewhere. While it is not wished to stress unduly the fasciation hypothesis of the origin of the ear it seems only fair to the adherents of such an hypothesis to ask why the lack of histological evidence for fasciation in the development of the ear should preclude this explanation when the same lack of evidence is not considered in the case of the normally fasiated stigmas and of conate seeds.

There are numerous misstatements and generalizations which should be corrected; thus on page 20—"Pod corn frequently appears by regressive variation in any variety" and on page 117 "Functionally perfect flowers are of rare occurrence" and on page 141, "Six-rowed ears have never been known to occur." The first and last of these statements, of course, are not according to the known facts and while the other may be a matter of opinion, there can be little question that the mutations to pod corn are much more rare than the occurrence of perfect flowers.

On page 38 we read "At about this time, or a little later, the last of the food stored in the endosperm is consumed and the new plant begins its independent existence." Notwithstanding this statement it is extremely doubtful whether a normal germinating maize plant consumes the last of the food stored in the endosperm and indeed the storage of material in the seed in excess of what is normally used is one of the outstanding features of the large-seeded varieties of maize.

On pages 44-45 it is stated "above the first or second internode wholly above the ground the succeeding mature internodes are thinner and longer" and on page 57 "In this branch the uppermost internodes are short, and the lower ones progressively longer—a condition exactly opposite that prevailing in the main culm." We have measured all the internodes on hundreds of maize plants and have found that in a vast majority of varieties, including the common commercial strains the longest internode is well below the ear and usually is midway between the lowest and the uppermost.

On page 78 "The best known and probably the most destructive disease of maize is smut or brand." This will reassure the growers who may have become alarmed by the root-rot propaganda.

On page 107 the author shows great caution in accepting the hereditary nature of fasciation and the inheritance of branched forms of ears is disparaged as being nothing more than

sporadic mutations. But what more is expected of them?

On page 184 we note that first generation hybrids are used extensively. Although the extensive use of such hybrids is greatly to be desired the above statement must be taken as a prediction rather than a fact.

These statements illustrate the futility of generalizations about this species and whenever found they should be the subjects of reservations by the reader.

It is to be regretted also that the distinctive name *brachytic* has been applied to an entirely different and unrelated form of dwarfing from that originally published under this designation.

It seems worthy of note that the abortion of parts ["which seems a characteristic of theories demanding it for consistency"] is now recognized as a common phenomenon in the normal development of the sex organs.

In the discussion of maize-teosinte hybrids the author discounts the results obtained thus far and urges postponement of further investigations along this line. The efforts of morphologists in the past, however, have not been such as to encourage geneticists to postpone further analysis of maize-teosinte hybrids with the hope that a "sound working basis of morphology" will be available.

Had the volume been limited more definitely to morphology, a field for which the author seems eminently fitted. it could have been recommended highly, having no more than the usual errors of observation and interpretation, but as constituted at present it falls seriously short of presenting the story of the maize-plant.

J. H. KEMPTON.

The Inheritance of Squinting

That squinting is definitely inherited, is the conclusion of Arthur Czellitzer, a Berlin oculist, who publishes a study of his cases in the *Archiv f. Rassen- und Gesellschafts-Biologic* (XIV, 4). More than 800 brothers and sisters of cross-eyed children have been examined, and data sought regarding their parents and other ancestors.

While the frequency of squinting in the general population is reported to be only one or two per cent, he found that 15.4 per cent of the brothers and sisters of cross-eyed patients were also affected. The author's pedigree charts lead him to the conclusion that cross-eyes depend on two distinct recessive factors. There seems to be some genetic difference between convergent and divergent strabismus, however.

P. P.

A Eugenics Advisory Bureau

A free public eugenic clinic is now open two afternoons a week in the Anthropological Institute of the University of Munich, Bavaria. An anthropologist and a physician are in attendance, to help inquirers to study their family histories intelligently and learn their own genetic constitutions, so far as is possible. The examination results in the preparation of a detailed report, of which one copy is given to the applicant and the other (identified only by a serial number) is kept by the Institute for the use of research workers. A charge is made for special services such as photographs and X-ray examinations. The bureau is known as the Beratungstelle fur biologische Familienforschung.

P. P.

NAKED OATS

T. R. STANTON

U. S. Department of Agriculture, Washington, D. C.

THE naked or hull-less oat is without doubt the proverbial "black sheep" of the cultivated oat family. In appearance it is very attractive and interesting, but it is always short on performance. Its oddity and attractive appearance make it readily salable to those who do not know it, and consequently it has been considerably exploited.

During the past fifty years naked oats have been advertised several times as a valuable new variety, with extravagant claims as to their yielding power and usefulness as compared with common oats. The purchaser in every case was "gold bricked" and became the unfortunate victim of the clever advertising of the promoter. The promoter's agents, traveling from farm to farm, showed with great enthusiasm a few kernels of the naked oats in small vials which they carried with them, proclaiming it to be one of the marvels of the age.

In the decade from 1870 to 1880, naked oats, under the name of Bohemian oats, were for the first time widely exploited in this country. They were known prior to this, but apparently had been given no serious consideration, especially as a plant novelty that would lend itself readily to spurious exploitation. During the period of the Bohemian oat scandal the seed was sold for as much as fifty cents a pound. The Bohemian oats were rather widely distributed, but farmers discovered that they were greatly inferior to ordinary oats and soon they had almost entirely disappeared from cultivation. However, sporadic exploitation of naked oats under other names has occurred up to the present day. Every spring the Office of Cereal Investigations, U. S. Department of Agriculture, receives letters from farmers requesting seed or information on naked or hull-less oats.

History

The origin of naked oats is not known, though they appear to have come originally from central and eastern Asia. This type of oats was grown in England as early as the middle of the sixteenth century. In some of the older English publications they are referred to as "peelcorn" and also as "skinless oats." Naked oats are now found in the dry Tibetan-Himalaya highlands in Russia and Chinese Turkestan, and in northern and western China. Indications are that they have grown in that part of the world for many centuries, the grain being used quite largely as human food. Practically all of the naked varieties received by the Office of Cereal Investigations were collected by the late Frank N. Meyer in the regions mentioned. He reports that they usually were found growing on sterile mountain sides at high altitudes.

Description

The chief distinguishing characteristic of naked oats is, as the name implies, the multiple-flowered spikelet with naked or hull-less kernels. The hull is not retained as in common oats, but the grain thrashes free from it. The number of flowers in the spikelet varies from three to twelve, the average number being about seven. The culms and leaves are similar to those of common oats, though the culm is usually shorter and weaker and lodges more easily. As in common oats, there are varieties with both spreading and side (horsemane) panicles, the latter being practically unknown in America.

A PANICLE AND SPIKELET OF NAKED OATS

FIGURE 14. The most desirable character possessed by the hull-less varieties of oats is the multiflorous spikelets (lower left-hand corner), which could be used to make hulled varieties much more prolific, were it possible to transfer the character to them. Unfortunately hull-lessness and multiflorous spikelets are very closely correlated or linked, and they never segregate separately in the second generation of crosses of naked by hulled oats. Naked oats is the black sheep of the family; it promises well but is always short on performance. Furthermore the grain does not keep long in storage as the lack of hulls seems to inhibit proper respiration. The panicle shown is of the variety known as Chinese Hull-less.

A PANICLE OF ORDINARY HULLED OATS

FIGURE 15. The variety is Swedish Select, one of the better commercial strains of oats. Note that only two grains normally develop on a spikelet, whereas in naked oats from four to twelve grains are found. Nevertheless the yield of this variety is much greater than that of the best varieties of naked oats. Naked oats are supposed to be native to Central Asia. They were introduced into England as early as the sixteenth century, and were called "peel-corn" or "skinless oats." They were known in this country early in the nineteenth century, but were not exploited as a superior "novelty" until 1870. At the time of the "Bohemian oats" scandal, seed sold for as much as fifty cents a pound.

There also are varietal differences in size and length of kernel, and in the presence and absence of awns. Panicles and spikelets of naked and common oats are shown in Figures 14 and 15, respectively.

Varieties

The number of varieties of naked oats is comparatively small. Most of the lots introduced into this country have been of the Chinese variety (*A. nuda chinensis*, Fisch.), with spreading panicles and with either awned or awnless lemmas. This variety is the one which has been most commonly exploited.

In recent years several new varieties of naked oats have been developed in this country by crossing the Chinese variety on some of the best common varieties. The most notable is that of the Liberty Hull-less, (Ottawa No. 480) (see Fig. 16) developed by Dr. C. E. Saunders of the Central Experiment Farms, Ottawa, Canada, from a cross between Chinese Hull-less and Swedish Select. Dr. Saunders succeeded in getting a stiffer strawed variety in the Liberty Hull-less, but in yield it apparently is not greatly superior to the Chinese Hull-less parent. It may also be slightly less susceptible to disease than the naked parent, all of the strains of naked oats which have been introduced into this country being very susceptible to smut and rust.

Recently the South Dakota Agricultural Experiment Station at Brookings has bred a new naked variety from a cross between Kilby Hull-less and Swedish Select. This new variety is practically identical with the Liberty Hull-less. One year's observation of this variety indicates that it is not superior to other naked varieties. The Department of Plant Breeding at Cornell University also has bred several new naked sorts from a cross between naked oats and Swedish Select.

Yield

The agronomic value of any crop variety is determined primarily by its yielding power. Naked oats have been included in a few scattered varietal experiments. The earliest reported experiments in which the naked variety was compared with ordinary ones were conducted by the University of Wisconsin at Madison in 1871. The results of these experiments as reported by McAfee,[6]* farm superintendent, shows that Bohemian Hull-less oats yielded 970 pounds of grain to the acre, as compared with 2,489 pounds of White Schonen, 1,992 pounds of common local oats, and yields of other varieties vary from 1,510 to 2,404 pounds.

In 1916, the Washington Agricultural Experiment Station at Pullman reported[10] some results with hull-less and other varieties of oats grown in 1913, 1914 and 1915. Only yields in grams per plat are shown, but these provide a basis for satisfactory comparisons. The average yield of naked oats for the three years was 1,456 grams; of Chinese Hull-less, 1,063 grams; of Abundance, 3,246 grams, and of Banner, 3,248 grams. If the yields of these two latter hulled varieties are reduced by twenty-five per cent, the approximate weight of the hulls, they are still in excess of 2,400 grams of dehulled grain.

Some of the more recent introductions of naked oats have been grown for one or two years at the field stations of the Office of Cereal Investigations. At some stations they were so poor that they were not thought worth harvesting. As a consequence, few yield data on hull-less varieties have been accumulated. Such data are available for 1914 and 1915 at both Moccasin, Montana, and Highmore, South Dakota, on one variety of naked oats. At Moccasin, the hull-less averages 1,098 pounds to the acre, as against 1,802 pounds of Swedish Select oats. At Highmore, the average yield of the

* For numbered references, see *Literature Cited*, at end of article.

PANICLE AND SPIKELET OF CROSS-BRED NAKED OATS

FIGURE 16. This is one of the improved varieties of naked oats developed in Canada. Heavier yields are obtained than from Chinese naked oats (Figure 14), and it is more resistant to rust. Nevertheless it is not a very desirable proposition from the farmer's standpoint, as the amount of grain produced is less than that of any of the standard hulled varieties. It was developed by Dr. Saunders, of the Ottawa Experiment Station, by crossing Swedish Select (Figure 15), and Chinese Hull-less (Figure 14), and is called Liberty Hull-less. Many of the leading plant breeders have tried to produce a strain of naked oats that would be superior to the hulled varieties, but so far none of them has been successful.

hull-less variety was only 224 pounds compared with 1,792 pounds produced by the Sixty-Day.

During the years 1917, 1918 and 1921, three varieties of naked oats were included in the oat nursery maintained by the Office of Cereal Investigations on the Aberdeen Substation, Aberdeen, Idaho. The average yields of these varieties were 4,134, 4,370 and 4,458 pounds, as compared with an average yield of 6,742 pounds from the Silvermine oat under the same conditions. Reducing the latter yield by twenty-five per cent, the normal weight of the hulls, the Silvermine still produced 5,057 pounds of kernels with the hulls removed, considerably more than any of the naked varieties.

The Liberty Hull-less has been included in recent nursery experiments at Cornell University. Its average yield for the three-year period from 1919-1921, inclusive, has been 961 pounds as compared with 1,850 and 1,710 pounds for Cornellian and Silvermine, respectively, two of the best common varieties.

These figures show clearly that naked oats cannot compete with common hulled oats in yield, the most valuable asset of any crop variety. Naked oats cannot be recommended for growing under field conditions, and it simply is a waste of time and money for farmers to attempt to grow them. Not until better yielding naked varieties are developed will it be possible to make a recommendation favorable to this type of oats.

Other Undesirable Characters

Even if naked oats compared favorably with ordinary oats in yield, it is very doubtful if they would be grown extensively because of the poor keeping qualities of the grain. It is difficult to store them in bulk in large quantities, as they go out of condition very quickly. The absence of hulls apparently affects the process of respiration in the kernel, and as a result deterioration takes place rapidly. Naked oats also lose their viability in a short time, seed a year old usually showing a very low percentage of germination.

Inheritance of the Naked Character

Naked oats have some value for hybridization, though they are of more interest to the geneticist in determining the mode of inheritance of certain characters than they are to the practical plant breeder. Some of these studies have been reported.

Norton[8], Zinn and Surface[12], Gaines[2], Love and McRostie[5], and Capron[1], have reported on studies of the mode of inheritance of the naked character in naked-hulled croses. Their results agree quite well and indicate rather definitely a simple monohybrid segregation in the second generation of one naked, two intermediate (with both naked and hulled oats in the same spikelet), and one hulled.

The main object of practical breeders such as the Gartons[3, 7] of England and Pringle[9, 4, 11] of Vermont in using naked oats for crossing was to obtain a many-flowered hulled variety. The results of recent investigations, however, particularly the work of Zinn and Surface, Caporn, and Love and McRostie, indicate that such a variety is impossible. They have shown that the many-flowered spikelet and naked kernel or membraneous palea are linked. For this reason the number of flowers is reduced in all plants which breed true for adherent palea (hulled condition). According to Capron, a biflorous naked form is possible, but from the practical aspect is not desirable. On the other hand, a multiflorous hulled form is very desirable, but seems impossible genetically.

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Bringing Up the Baby

Nursery Guide, by Louis W. Saur, M. D., Senior Attending Pediatrician, Evanston Hospital. Illustrated with 11 figures. Pp. 188. Price, $1.75. The C. W. Mosby Co., St. Louis, 1923.

Of at least indirect interest to eugenists is the problem of raising children after they are born. As an aid to this, "Baby Books" are of no small value. Perhaps as more of them come into being, that much discussed quality, intelligence will be given a survival value by reason of the fact that only the exceptional mother will be able to unravel the meaning of some of the phrases used in them.

The most valuable innovation in this volume and one that is only inadequately used, is to illustrate the more complicated phases of "bringing up the baby" by means of photographs. However, even a beginning in this direction is to be commended, and we hope that the idea can be extended and amplified in later editions.

The book contains very few statements regarding heredity, but on the first page of the text is one that is certainly open to misinterpretation: "Tuberculosis is not inherited, but is acquired some time before or after birth."

As it stands, the statement is true, but it is misleading in that no mention is made of the important role of heredity in determining whether tuberculosis will or will not be acquired. Recent investigations indicate that this "indirect heredity" is all-important. We are all exposed to tuberculosis, but those individuals who have inherited a susceptibility to the disease are much more likely to fall victims to it than others living under similar conditions who come of resistant stock.

Eugenics in Germany

Privat-dozent Dr. Fritz Lenz, one of the editors of the Archiv fuer Rassen- und Gesellschaftsbiologie, has been appointed Professor of Race Hygiene (the German equivalent of eugenics) at the University of Munich. This is the first professorship in Germany to be devoted to eugenics under the name, although Heinrich Poll has for some years occupied a chair of "human genetics" at the University of Berlin.

WISCONSIN "EUGENICS LAW" NOT REPEALED

ACCORDING to a widely circulated report the so-called Wisconsin "Eugenics Law" has been repealed. As a matter of fact, this does not appear to be the case, although it is questionable whether keeping the law on the statute books has any great eugenic value. After considerable debate by the Wisconsin Legislature the old law was extended if not strengthened by adding a clause requiring women to file an affidavit that they are free from social diseases before a license to marry will be issued.

The original law was passed in 1914 and required "A medical examination of all male persons making application to marry." Later the courts ruled that it was not the intention of the Legislature to require the Wasserman test as part of the examination. This had the effect of further reducing the already limited usefulness of the measure.

It is greatly to be deplored that such legislation should be connected in name with eugenics. The limited provisions of the law in the first place, and the way it has been administered show that it has little eugenic value. Perhaps the history of this law points a moral: that much research and a vast amount of education in the elementary principles of biological inheritance must come before sound legal action is possible and would receive the necessary public support. In a eugenically enlightened community with the importance of heredity properly appreciated, and the fact of the inheritance of many weaknesses both mental and physical generally realized, the right kind of pre-marriage examination would be of no small value. Until there is wide public appreciation of these facts it is impossible that many people would have the biological backgroumd to place the proper interpretation on the results of such an examination. The only effects that it has today are most certainly dysgenic. Serious-minded people, who appreciate their responsibility to future generations, are undoubtedly often deterred from marriage by such an examination, and for no sound biological reason. On the other hand, those who lack the mental capacity to realize the consequences of their acts are not led by it to forego marriage. Such a law must be backed by educated public opinion if its enforcement is to be either intelligent or effective.

The Mathematics of Life

MATHEMATIK UND BIOLOGIE, by MARTIN SCHIFS. Mathematical and Physical Library, Volume 42. Pp. 52; 16 figures. Price, 19 cents. Leipzig, Verlag von B. G. Tuebner, 1922.

This little booklet is not, as one might expect, a discussion of biometry, but rather an account of some of the mathematical relations existing within an individual living organism. The symmetry of organisms finds one of its most complicated illustrations in the arrangement of leaves on the stem of a plant, according to formulas which can be worked out definitely, and formed the basis, a score of years or so past, of a study that enjoyed some popularity, namely, phyllotaxy. The size-relations of an organism are also discussed under the head of morphology. The second part of the book is given up to anatomy and physiology. It considers such problems as the mechanics of bones, muscles, and blood vessels, and ends with a discussion of Weber's Law. While all these subjects are more or less familiar to the student, it is worth while to have them brought together and correlated; and the formulas which the book contains will also be found convenient for reference. —P. P.

A MULTIFLOROUS VARIATION IN BURT OATS

F. A. COFFMAN and K. S. QUISENBERRY[1]

U. S. Department of Agriculture.

A STUDY of variation in Burt oats[2] has been conducted during the past several years at the Akron Field Station of the United States Department of Agriculture at Akron, Colo., and at the Kansas Agricultural Experiment Station, Manhattan, Kans. In this study, a plant appeared in a strain of Burt, C. I. No. 1921,[3] grown at Akron in 1920, which showed the multiflorous spikelet correlated with the naked (hull-less) condition characteristic of *Avena nuda*. The outer glumes of the spikelets were long, resembling those of *Avena nuda*. The spikelets were from two to six flowered, with elongated rachillas, causing the florets to extend beyond the outer glumes.

The lemma and palea were of a dark brown color and the caryopsis [kernel] was larger than is common with the naked oats (Fig. 17). Approximately forty per cent of the seeds thrashed free from the flowering glumes. The percentage of naked seeds in the spikelet did not appear to vary with the position of the spikelet on the panicle. The panicle of the variation shown in comparison with ordinary hulled and naked oats in Figure 21 presented, in part, the appearance of a hulled × hull-less first generation hybrid as described by Norton (6),[4] Zinn and Surface (8), Gaines (2), Caporn (1), and Love and McRostie (4). Norton observed one plant resulting from the cross, European Hull-less × Garton's Tartar King, which he states "seems to have become fixed in the intermediate type. In this example we have an extremely rare case of the fixation of a heterozygote or hybrid state." Farther than this statement no information regarding this peculiar form seems to have been published. Hulled and naked kernels from panicles bearing naked seeds, hulled seeds from normal panicles and ordinary naked kernels are shown in Figures 19 and 20.

The particular strain of Burt oats in which this variation appeared originated at the Iowa Agricultural Experiment Station, Ames, Iowa. It was introduced into the agronomic nursery at the Kansas Agricultural Experiment Station, Manhattan, Kans., in 1918. So far as the history at the Kansas station is known, this selection had never been grown adjacent to or even near any *Avena nuda* types.

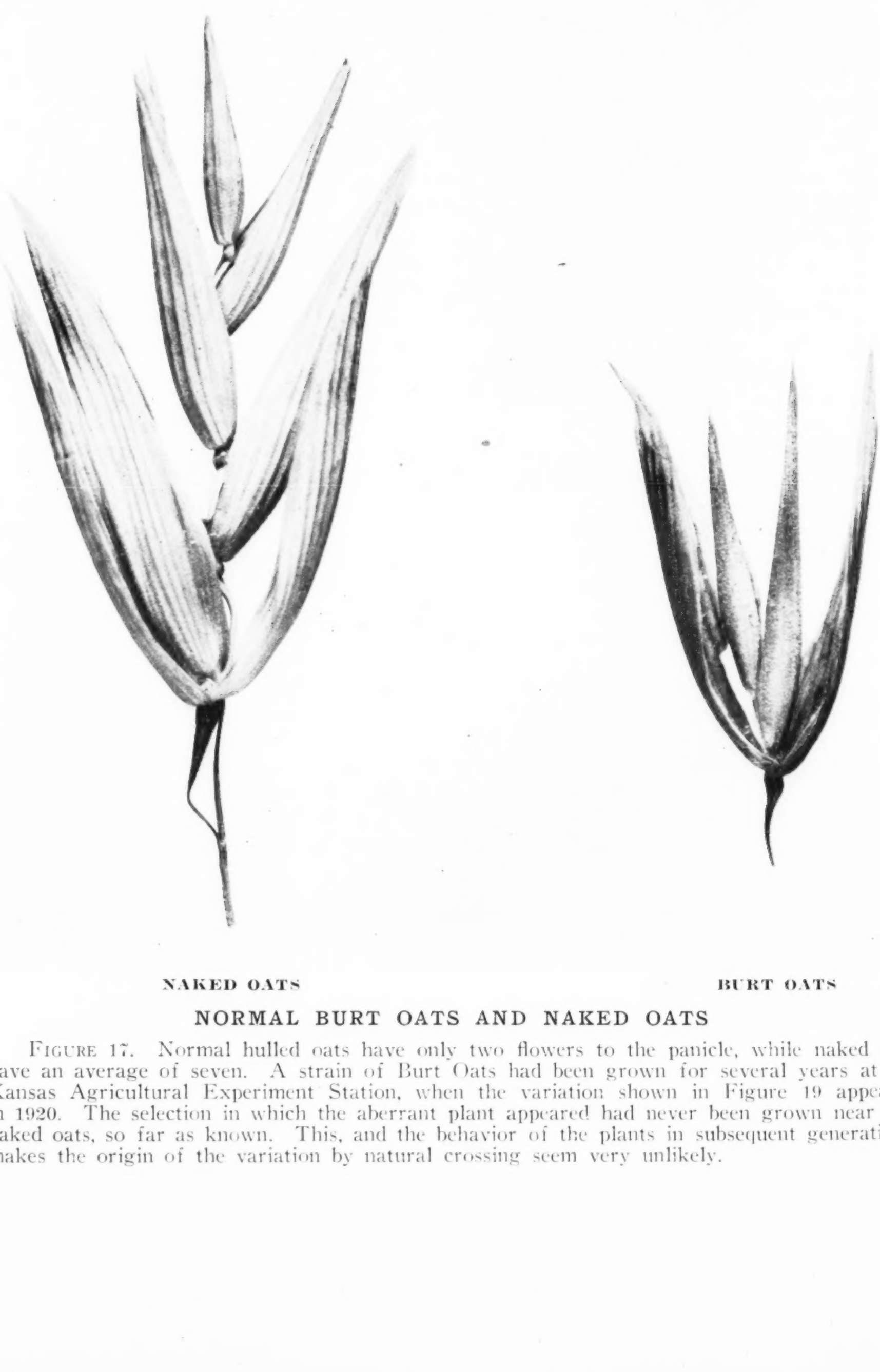
The kernel from which the plant under discussion was grown was described as being of the *sativa* type of

[1] This study has been conducted by F. A. Coffman, assistant agronomist, Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, located at the Akron Field Station, Akron, Colo., by K. S. Quisenberry, working both at the Kansas Agricultural Experiment Station, Manhattan, Kans., and the West Virginia Agricultural Experiment Station, Morgantown, W. Va. The writers are indebted to Prof. John H. Parker, in charge of crop improvement at the Kansas Agricultural Experiment Station, and to C. W. Warburton, in charge of cereal agronomy experiments in the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, for many helpful suggestions and criticisms in the preparation of this paper.

[2] The study of variation in Burt oats has been conducted as a cooperative problem at the Akron Field Station, Akron, Colo., and the Kansas Agricultural Experiment Station, Manhattan, Kans.

[3] Cereal Investigations accession number.

[4] Figures in parenthesis refer to *Literature Cited*, at end of article.



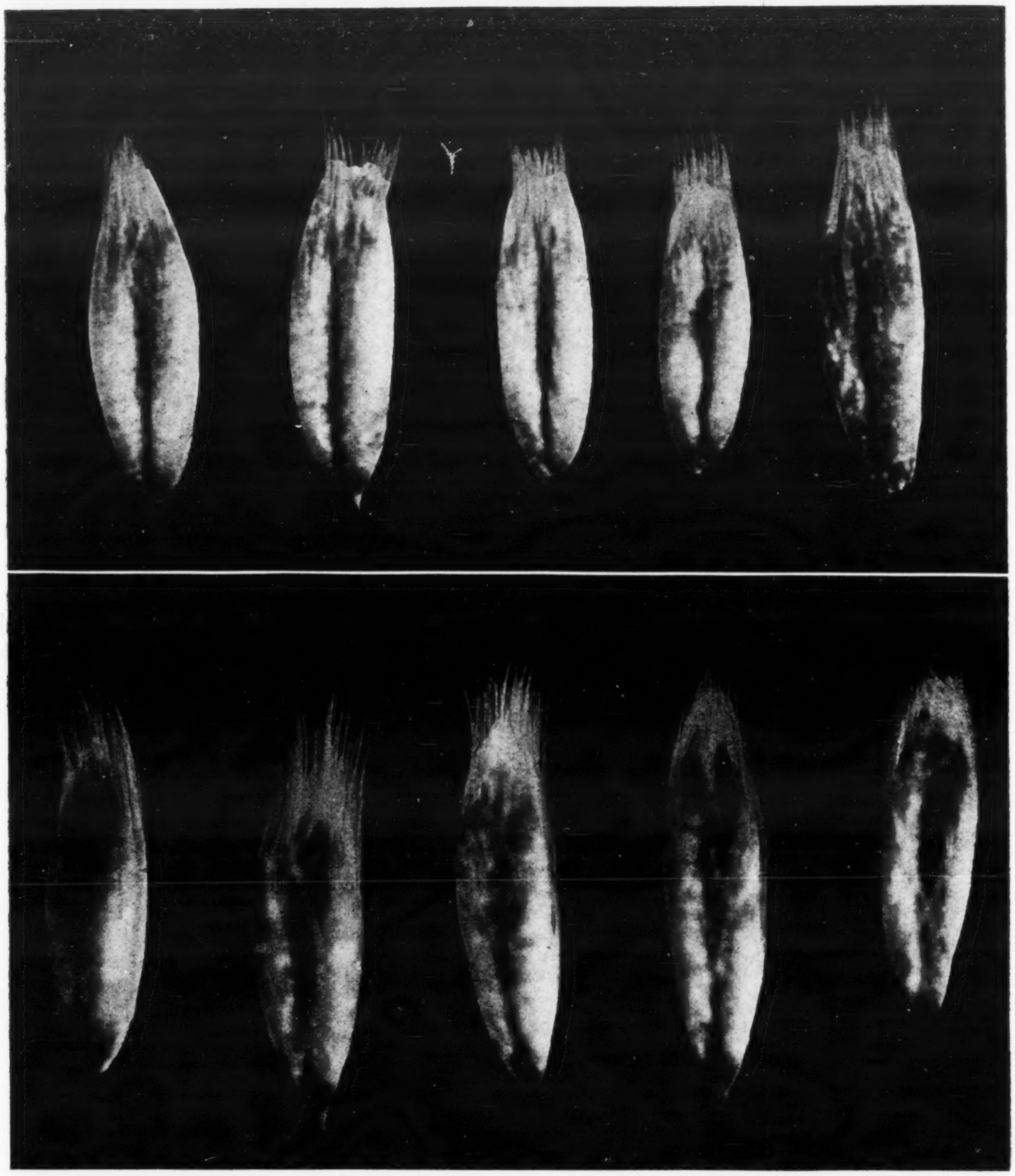
NAKED OATS BURT OATS

NORMAL BURT OATS AND NAKED OATS

FIGURE 17. Normal hulled oats have only two flowers to the panicle, while naked oats have an average of seven. A strain of Burt Oats had been grown for several years at the Kansas Agricultural Experiment Station, when the variation shown in Figure 19 appeared in 1920. The selection in which the aberrant plant appeared had never been grown near any naked oats, so far as known. This, and the behavior of the plants in subsequent generations, makes the origin of the variation by natural crossing seem very unlikely.

THE MULTIFLOROUS VARIATION IN BURT OATS

FIGURE 18. Notice how much this form resembles naked oats except for the dark color of the spikelet, and the hardened glume tissue, which are not characteristic of *Avena nuda*. The multiflorous character would be very valuable to the breeder if it could be linked with the hulled condition. Unfortunately, even in this mutation the multiflorous spikelet and the hull-less kernels are found together, although in an intermediate form. The plants of this variation mature several days earlier than other varieties with which they were grown. No data has been obtained as to yield, in comparison with either hulled or naked oats.



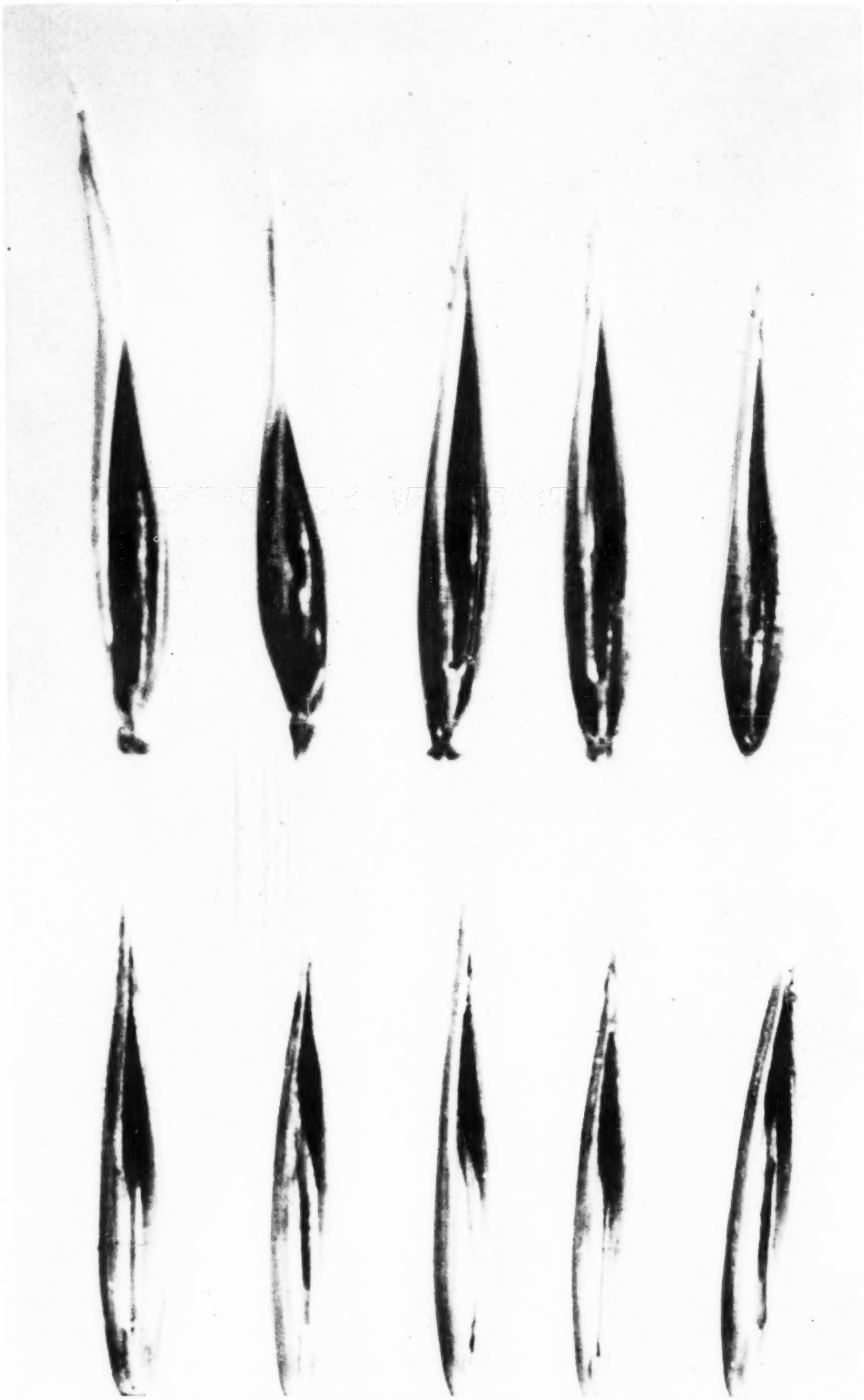
NAKED KERNELS OF BURT OATS AND HULL-LESS OATS

FIGURE 19. The grains of hull-less oats (top) are somewhat smaller and lighter in color than naked seeds of the Burt variation (bottom). The cause of the multiflorous variation is not known, but it appears to be due to a mutation rather than to natural crossing.

articulation, having no basal scar or basal pubescence. It had a brown glume and a weak awn. This kernel, along with several thousand others, was sown at Akron, Colo., April 29, 1920. The plant headed June 21, which was five days earlier than the average for the parent strain. Of 227 plants of this strain of Burt, but ten reached the heading stage before June 21. With the exception of the panicle, the characters of the plant did not vary greatly from the average of the parental strain.

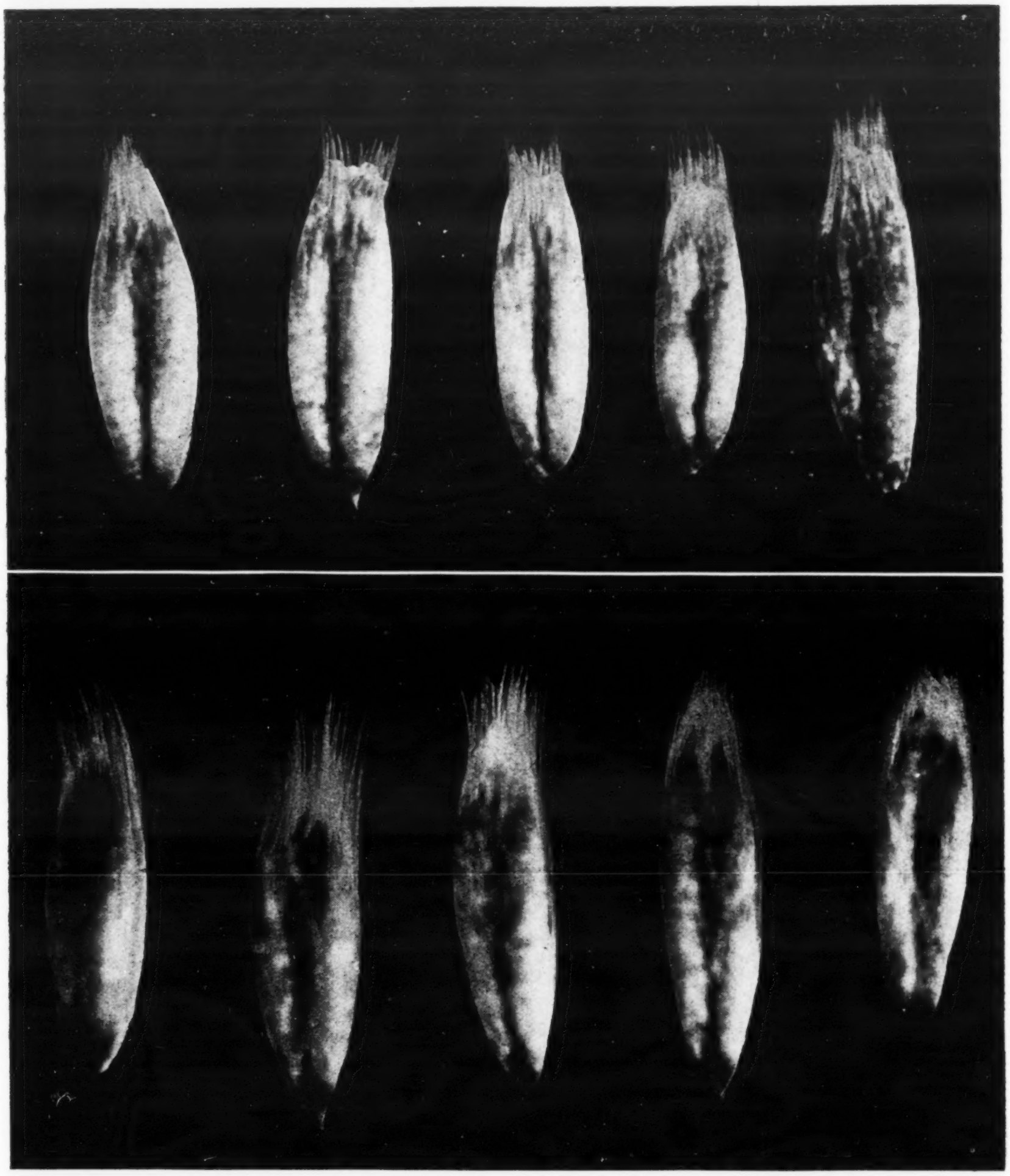
Experimental Data

In 1921, kernels from the variant were sown at the Akron Field Station and at the Kansas Agricultural Experiment Station. Several unfavorable factors influenced the results obtained at the two stations. Weather conditions at Akron in 1921 were very adverse, and as a result of dry weather and the ravages of locusts but forty-three plants were grown to maturity from a total of eighty-one kernels sown. The plants at the Kansas station fared little better, injury by chinch



HULLED KERNELS OF BURT OATS

FIGURE 20. About forty per cent of the spikelets of the aberrant plants produce naked grains, the rest of the kernels being hulled like those shown above (top row). Both hulled and naked grains are found on different spikelets of the same plant. These grains of the multiflorous variation are darker and somewhat larger than the normal Burt oats (lower row)



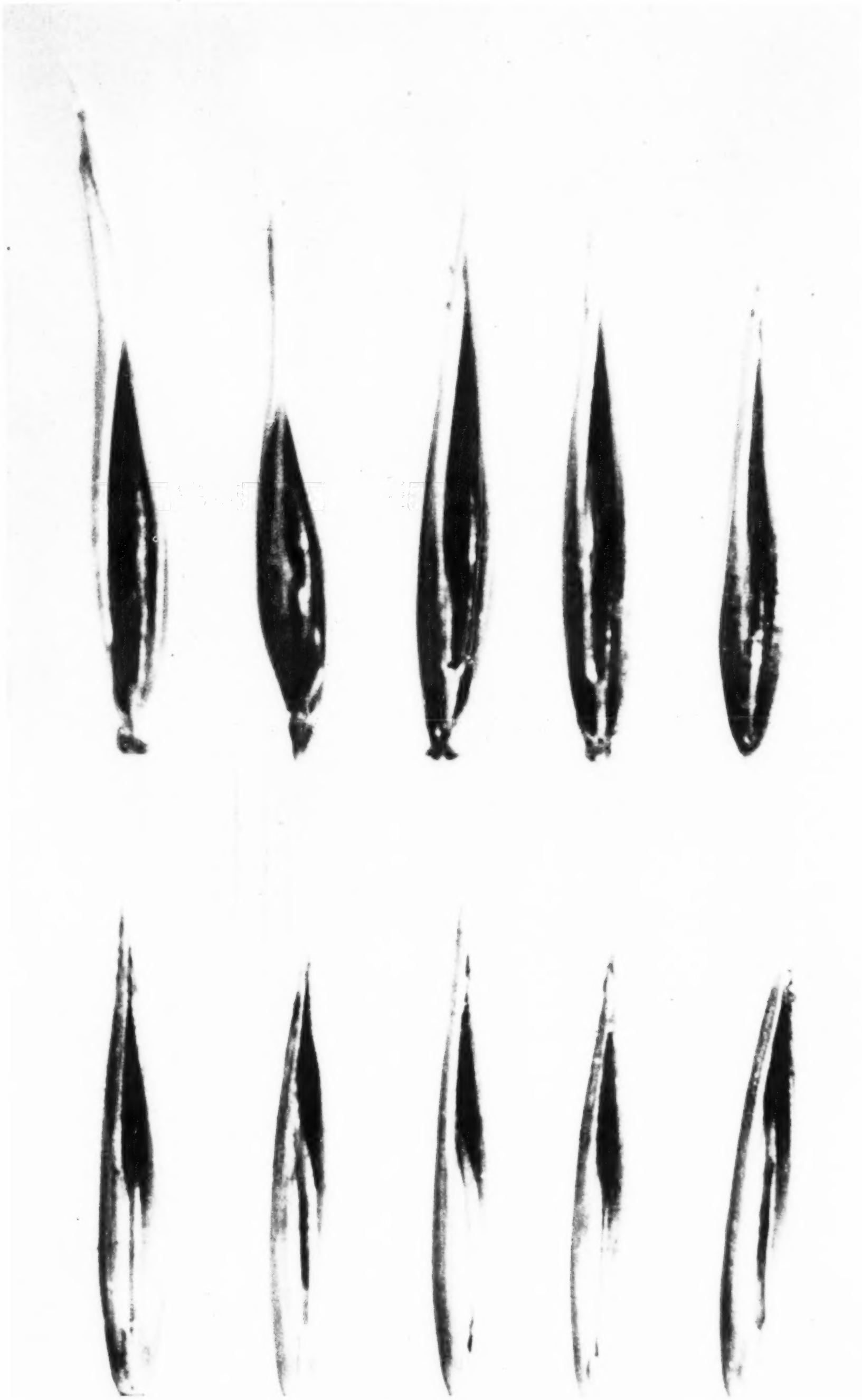
NAKED KERNELS OF BURT OATS AND HULL-LESS OATS

FIGURE 19. The grains of hull-less oats (top) are somewhat smaller and lighter in color than naked seeds of the Burt variation (bottom). The cause of the multiflorous variation is not known, but it appears to be due to a mutation rather than to natural crossing.

articulation, having no basal scar or basal pubescence. It had a brown glume and a weak awn. This kernel, along with several thousand others, was sown at Akron, Colo., April 29, 1920. The plant headed June 21, which was five days earlier than the average for the parent strain. Of 227 plants of this strain of Burt, but ten reached the heading stage before June 21. With the exception of the panicle, the characters of the plant did not vary greatly from the average of the parental strain.

Experimental Data

In 1921, kernels from the variant were sown at the Akron Field Station and at the Kansas Agricultural Experiment Station. Several unfavorable factors influenced the results obtained at the two stations. Weather conditions at Akron in 1921 were very adverse, and as a result of dry weather and the ravages of locusts but forty-three plants were grown to maturity from a total of eighty-one kernels sown. The plants at the Kansas station fared little better, injury by chinch



HULLED KERNELS OF BURT OATS

FIGURE 20. About forty per cent of the spikelets of the aberrant plants produce naked grains, the rest of the kernels being hulled like those shown above (top row). Both hulled and naked grains are found on different spikelets of the same plant. These grains of the multiflorous variation are darker and somewhat larger than the normal Burt oats (lower row)

bugs preventing all but sixteen plants from maturing seed. Although the 1921 experiments were affected by several unfavorable conditions, the results obtained were of a convincing nature. In all cases the plants grown at both stations presented an appearance closely approximating that of the original plant variant. Some plants resembled the characters of *Avena nuda* more closely than others, but no plants were found which resembled the hulled oat type to a very marked degree.

In 1922, kernels from each of the plants of the variant grown at the Akron station in 1921 were sown on April 27. A total of about two hundred kernels was sown, from which one hundred ninety-three plants grew to maturity. The plants were unusually early in heading and most of them had fully matured by July 16. It was found, on closely examining the panicles, that all but one of the plants presented the intermediate hulled-naked form of the original variation discovered in 1920. One plant bearing two small panicles was observed in the material grown at Akron in 1922, which bore only naked kernels. This plant closely resembles the other plants of this peculiar strain of Burt oats in all other respects, however, and does not appear to be a true *Avena nuda*. Whether it will reproduce this naked condition can be determined only by growing progeny from it.

The weather at Akron, Colo., in 1922, was very dry during the time these plants were maturing, and as a result the color of the glumes of the oat kernels was perfectly developed. It was of interest to discover that in some panicles the glumes were very nearly black.

A total of 150 kernels of the variant was sown in the Plant Breeding Nursery at Morgantown, W. Va., in 1922. From these about one hundred plants developed. These plants were the earliest forms in the nursery, heading several days before any of the other oats. All of the plants again showed the intermediate form, characteristic of the original variant.

Discussion

The cause of this multiflorous variation in Burt oats is not definitely known. Natural crosses are known to occur in oats and have been reported by various plant breeders. For a natural cross to occur it would have been necessary for the Burt strain, C. I. No. 1921, to have been grown near a naked form, and so far as is known this did not occur at the Kansas Agricultural Experiment Station at Manhattan, Kans., in 1919, when the strain was grown at that station. If the variation was due to a cross, segregation such as has been reported by various plant breeders for hulled × naked crosses would be expected. During the three seasons this plant variant and progeny from it have been grown, segregation has been noticed in only one case, and this segregating plant more closely resembles the multiflorous variant from which it originated than it does the *Avena nuda* form. If this form originated from a hulled × naked cross, the progeny should, according to those who have investigated crosses between hulled and naked forms, have segregated into hulled, intermediate, and naked forms in the ratio of 1:2:1, in the 1921 crop. According to Gaines (2), the development of color is supposed to be inhibited by the naked character in segregates of hulled × naked crosses. Panicles in which the glume color is very well developed are not difficult to find in the plants of this variation and some plants which have almost black glumes have been observed.

Various mutations have been reported in oats, both in plant and seed characters. Nilsson-Ehle (5) noted the occurrence of white or gray individuals in black varieties. Warburton (7) found dwarf forms of plants appearing in the Victory variety. The seed from these dwarf forms, when planted, bred true. No explanation of

NAKED OATS MULTIFLOROUS BURT OATS NORMAL BURT OATS

NAKED OATS AND BURT OATS

FIGURE 21. The multiflorous variation of Burt oats looks not unlike a first generation hybrid between hulled and naked oats, as described by other authors. However, its genetic behavior is entirely different. No segregation occurs in later generations, which would be expected if the form were a hybrid.

bugs preventing all but sixteen plants from maturing seed. Although the 1921 experiments were affected by several unfavorable conditions, the results obtained were of a convincing nature. In all cases the plants grown at both stations presented an appearance closely approximating that of the original plant variant. Some plants resembled the characters of *Avena nuda* more closely than others, but no plants were found which resembled the hulled oat type to a very marked degree.

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NAKED OATS AND BURT OATS

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the occurrence of the dwarfs is given except that there was no evidence of hybridization. Love and McRostie (4) report forms similar to naked oats, which, they indicate, may have originated through mutative changes. In a pure line of Sixty-Day, spikelets appeared similar to true naked forms. The kernel was loosely held in the glumes and an increased number of flowers developed per spikelet. When sown, these seeds produced plants which did not reproduce this naked tendency. Garber (3) describes forms of false wild oats appearing in Victory, Garton No. 784, and Aurora, and states that "these aberrant forms may be attributed more logically to mutations than to natural crossing."

Summary

Numerous reports on controlled crosses of hulled × naked oats have been published. All of these reports have shown segregation in the second hybrid generation in the ratio of 1 hulled: 2 intermediate: 1 naked. A total of fifty-nine progeny plants of the variant multiflorous forms was grown in 1921, and 300 progeny plants were grown from these in 1922. Variation in the characters of the covered kernels of the progeny plants has been noticed, but as yet only one case of segregation of the plants into either the hulled or naked forms has occurred. The one apparent segregate was an under-developed individual and, except that it bore only naked kernels, closely resembled the other plants of the variant type.

It is difficult to explain the origin of the multiflorous variation in Burt oats on the basis of natural crossing, although natural crossing is believed to occur in oats to some extent. The genetic behavior of this variation is not in agreement with the results of those who have reported on crosses of hulled × naked oats. It appears, therefore, that this intermediate multiflorous variation may have resulted from mutation rather than by natural hybridization.

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